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FISH DISCHARGE RESIDENCY STUDY, PICKERING NGS B POSTOPERATIONAL STUDY, 1988

Report No 89-253-K

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Chemical Research Department

ABSTRACT

A fish discharge residency study was conducted in the Pickering NGS A and B discharges, for a second year, from March through July of 1988. White sucker, carp, smallmouth bass, yellow perch, and walleye were present on most diving occasions in the Pickering NGS A discharge. White sucker, carp, gizzard shad, smallmouth bass, white bass, freshwater drum, walleye, American eel and rock bass were present during dives made in the Pickering NGS B discharge. The discharges provide suitable spawning substrate for smallmouth bass. Of six smallmouth bass nests found in the Pickering NGS A discharge, two were active. In the Pickering NGS B discharge, 20 of the 34 nests located were active. Smallmouth bass spawning in the Pickering NGS B discharge may result in an increase in the local population, due to increased suitable spawning habitat. However, it is not known whether smallmouth bass spawning in the discharges has resulted in recruitment to the local population. Gizzard shad were not present in very high numbers at either discharge. No large walleye influxes were observed in the discharges during the dives, and gill net catches at the mouth of the discharge channels gave no indication of large nocturnal influxes of walleye into the discharges. Suitable substrate for walleye spawning exists in both discharges.

job	file	date	report no.
34-185-492	837.321PIC	December 21, 1989	89-253-K

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EXECUTIVE SUMMARY

FISH DISCHARGE RESIDENCY STUDY, PICKERING NGS B POSTOPERATIONAL STUDY, 1988

L.P. King and J.K. Kwik
Biological Research Section
Chemical Research Department

A fish residency study was conducted in the Pickering NGS A and B discharges for a second year, from March through July of 1988. The study was requested by the Environmental Studies and Assessments Department of the Design and Development - Generation Division of Ontario Hydro on behalf of the Pickering Engineering Department. It is part of the third year of a three-year Pickering NGS B postoperational aquatic program initiated in 1986.

Hypotheses concerning the effects of the thermal discharges on fish populations were formulated at a workshop held with the purpose of designing the Pickering NGS B postoperational studies (Greig et al. 1986). The 1987 and 1988 fish discharge residency studies were concerned with the hypotheses postulated for smallmouth bass, gizzard shad and walleye. The results of the 1988 discharge residency study are presented in this report.

The hypothesis concerning smallmouth bass was that suitable spawning habitat in the discharges would result in an increase in the local population. In the case of gizzard shad, it was hypothesized that the attraction of gizzard shad to the thermal discharge and thermal plume would lead to impingement of large numbers of gizzard shad which would interfere with station operation. The hypothesis formulated for walleye was that they would be attracted to the rapid discharge current during spawning. However, the elevated temperatures in the discharge would result in hatch advancement and increased egg mortality. Together with reduced larval survival due to entrainment, predation and asynchrony with their food source, these factors could result in a decrease in walleye stock.

Gamefish such as smallmouth bass, white bass and walleye were relatively abundant in the discharges during the winter and appear to be attracted to them.

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White sucker, carp, smallmouth bass, white bass, yellow perch, and walleye were present in the Pickering NGS A discharge on most diving occasions between March 22 and June 21, 1988. White sucker, carp, gizzard shad, smallmouth bass, white bass, freshwater drum, walleye, American eel and rock bass were present in the Pickering NGS B discharge during most dives made between March 22 and June 28, 1988.

Both discharges provide suitable spawning habitat for smallmouth bass. Although smallmouth bass spawning activity occurred in the Pickering NGS A discharge, no successful nesting was observed. Factors that contributed to the lack of spawning success in the Pickering NGS A discharge included water depth, shoreline orientation, and predation.

In the Pickering NGS B discharge, smallmouth bass spawning was first noted on May 25 and continued through July 11. Of a total of 34 nesting attempts, 20 active nests were observed over the study period. The nests were located in protected areas where the water was calm, along the west side of the discharge channel. Spawning of smallmouth bass in the Pickering NGS B discharge may result in an increase in the local population. However, it is not actually known whether smallmouth bass spawning in the discharges has contributed to recruitment.

Gizzard shad were not present in very high numbers in either discharge. However, they were caught regularly in gill nets set in the plume. Low numbers observed during the present study, as well as during the 1987 study, do not preclude the possibility of massive impingement of gizzard shad at Pickering NGS since the number of winter observations in both years were limited. In addition, impingement records of gizzard shad indicate that yearly fluctuations in abundance can be considerable.

Walleye were present in the discharges on all diving days except June 28. No large influxes were observed at their expected spawning time. However, their position in the discharge suggested that they were attracted to the discharge by the strong currents. In addition, since walleye spawning occurs at night, the daytime diving observations do not preclude the possibility that walleye may spawn in the discharges. Suitable spawning substrate for walleye is present in both discharges.

Gill net catches at the periphery of the discharges gave no indication of large nocturnal influxes of walleye into the discharges. However, recent observations at Ontario Hydro study sites at Atikokan TGS and Big Chute, indicated that walleye swim very close to shore as they move in to spawn at night (personal comm. Ed Checko and Paul Patrick). The placement of our nets precluded catching fish close to shore. The presence of eggs in entrainment samples collected at Pickering NGS in 1988 and the presence of a juvenile walleye in the stomach of a brown trout caught at the Pickering NGS A discharge during the 1988 fish survey suggest that walleye spawn in the area of Pickering NGS.

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To

Dr. R.W. Effer
Manager
Environmental Studies and Assessments Department
Design and Development - Generation Division

FISH DISCHARGE RESIDENCY STUDY, PICKERING NGS B POSTOPERATIONAL STUDY, 1988

1.0 INTRODUCTION

A fish discharge residency study was conducted from March 15 to June 21, 1988 in the Pickering NGS A discharge, and from March 15 to June 28, 1988 in the Pickering NGS B discharge. The study was requested by the Environmental Studies and Assessments Department of the Design and Development - Generation Division on behalf of the Pickering Engineering Department. It was part of the third year of a three-year Pickering NGS B postoperational aquatic program initiated in 1986. A fish discharge residency study was also conducted in the second year of the Pickering NGS B postoperational program in 1987. The results of that study are presented in Ontario Hydro Research Division Report No 88-267-K.

Pickering NGS B is a nuclear station consisting of four CANDU powered 540 MW units (Units 5-8) located on the north shore of Lake Ontario at Pickering, Ontario. Pickering NGS A, which also consists of four CANDU powered 540 MW units (Units 1-4) is situated on the west side of Pickering NGS B.

The two stations share a common surface condenser cooling water intake. Pickering NGS B discharges its cooling water to the east of the development while Pickering NGS A discharges to the west. The calculated temperature increase across the condenser with two pumps per unit and four units operating is estimated at 9.2°C for Pickering NGS B and 9.7°C for Pickering NGS A (RMEP-IR-07211-1). Pickering NGS B uses 33.4 m^3 of cooling water per unit per second and Pickering NGS A uses 30.8 m^3 per unit per second.

Hypotheses concerning the effects of the thermal discharges on fish populations were formulated at a workshop held for the purpose of designing the Pickering NGS B postoperational studies (Greig et al 1986). The 1987 and 1988 fish discharge residency studies were concerned with the hypotheses postulated for smallmouth bass, gizzard shad and walleye.

In the case of smallmouth bass, the hypothesis was that favorable habitat characteristics and elevated temperatures would attract them to the discharge. Spawning in the thermal discharge would be advanced, resulting in increased growth periods and in turn, increased survival of young-of-the-year. Surviving larvae would be recruited to the local smallmouth bass population.

The hypothesis for gizzard shad was that the thermal discharge and thermal plume would lead to impingement of large numbers of gizzard shad which would interfere with station operation. Since shad prefer warm water, it was assumed that they would be attracted to the thermal plumes resulting in increased numbers in the discharges. These increased densities of gizzard shad would result in increased impingement when recirculation of discharged water occurs. Balesic (Ontario Hydro Research Division Report No 77-400-K) indicated that gizzard shad are unusually susceptible to sudden temperature drops when warm-acclimated, hence their vulnerability to entrainment. Massive impingement during storm events could result in disruption of station operation.

The hypothesis for walleye was that the thermal discharge and presence of Pickering NGS would decrease the walleye stock. It was postulated that the rapid currents would attract walleye to the discharge. The fast currents and elevated temperatures in the discharge channel provide optimal conditions for walleye spawning. However, the elevated temperatures in the discharge result in hatch advancement and increased egg mortality. In addition, walleye larval survival may be reduced due to low food supply, predation and entrainment.

The objectives of the present study were to identify fish species that reside in the plume during the winter and early spring, to assess the abundance of gizzard shad, walleye and smallmouth bass in the discharges, and to determine whether walleye and smallmouth bass spawn in the discharges. In addition, although May to November fish surveys have been conducted around Pickering NGS B since 1979 (Ontario Hydro Research Division Report Nos 83-435-K, 84-135-K, 84-341-K, 87-149-K, 87-194-K and 89-149-K), winter and early spring fishing efforts are lacking. The discharge fish residency studies add to our knowledge of the winter and early spring fish species composition around the Pickering NGS A and B discharges.

2.0 METHODS

Observations on fish resident within the discharge channel were obtained by SCUBA equipped divers. Dives were scheduled from January through July. However, poor visibility in the discharges precluded diving in January and February of 1988 and limited diving frequency in the remaining months. A total of eight dives were made in the Pickering NGS A discharge and ten dives were made in the Pickering NGS B discharge.

Divers swam along the walls and bottom of the discharge channels. The discharges were divided into zones (Figures 1 and 2) and observations were recorded for each zone. Dives were made during the daytime and lasted approximately 20 minutes per discharge channel side (40 minutes diving time per discharge).

Due to poor visibility, zone 4 in the Pickering NGS B discharge could not be surveyed on May 11, and zones 3 and 4 could not be surveyed on June 28, 1988.

Fish observed singly or in small groups were counted while numbers of fish observed in large schools were estimated. Temperatures were recorded at the start of the dives. Observations were also made on substrate and water current direction.

Mean daily intake and outfall temperatures were obtained from Environmental Protection Department, Central Production Services Division of Ontario Hydro.

To determine whether there was movement of spawning walleye into the discharges at night, gill nets were set at the periphery of the discharges: to the west of the Pickering NGS A discharge and to the east of the Pickering NGS B discharge. Gill netting was conducted on six occasions, approximately weekly, from mid-March through late-April at each of the two discharges.

Gill nets consisted of eight 15 m panels with mesh size increasing in 1.3 cm increments from 3.8 cm to 12.7 cm. The nets were set along the bottom, perpendicular to shore, for 24-hour periods.

Smallmouth bass spawning observations were made by snorkeling along the sides of the discharges. Number and placement of nests and development of broods were recorded from May 25 to July 11.

3.0 RESULTS AND DISCUSSION

3.1 OPERATION RECORD

Pickering NGS A had two to three units operational from March to July, 1988. Unit 2 was out of operation throughout the study period for pressure tube replacement. Otherwise, outages were few and of short durations with the exception of a 28-day outage for unit 3 in March-April for a pressure tube inspection and a 10-day outage for Unit 1 in June-July.

Pickering NGS B had four units operating in March and April and three units from May through July. With the exception of a short down period for unit 6 in July, the down time was accounted for by unit 8 which had a planned outage for boiler tube inspection which lasted from May 13 to July 10, 1988.

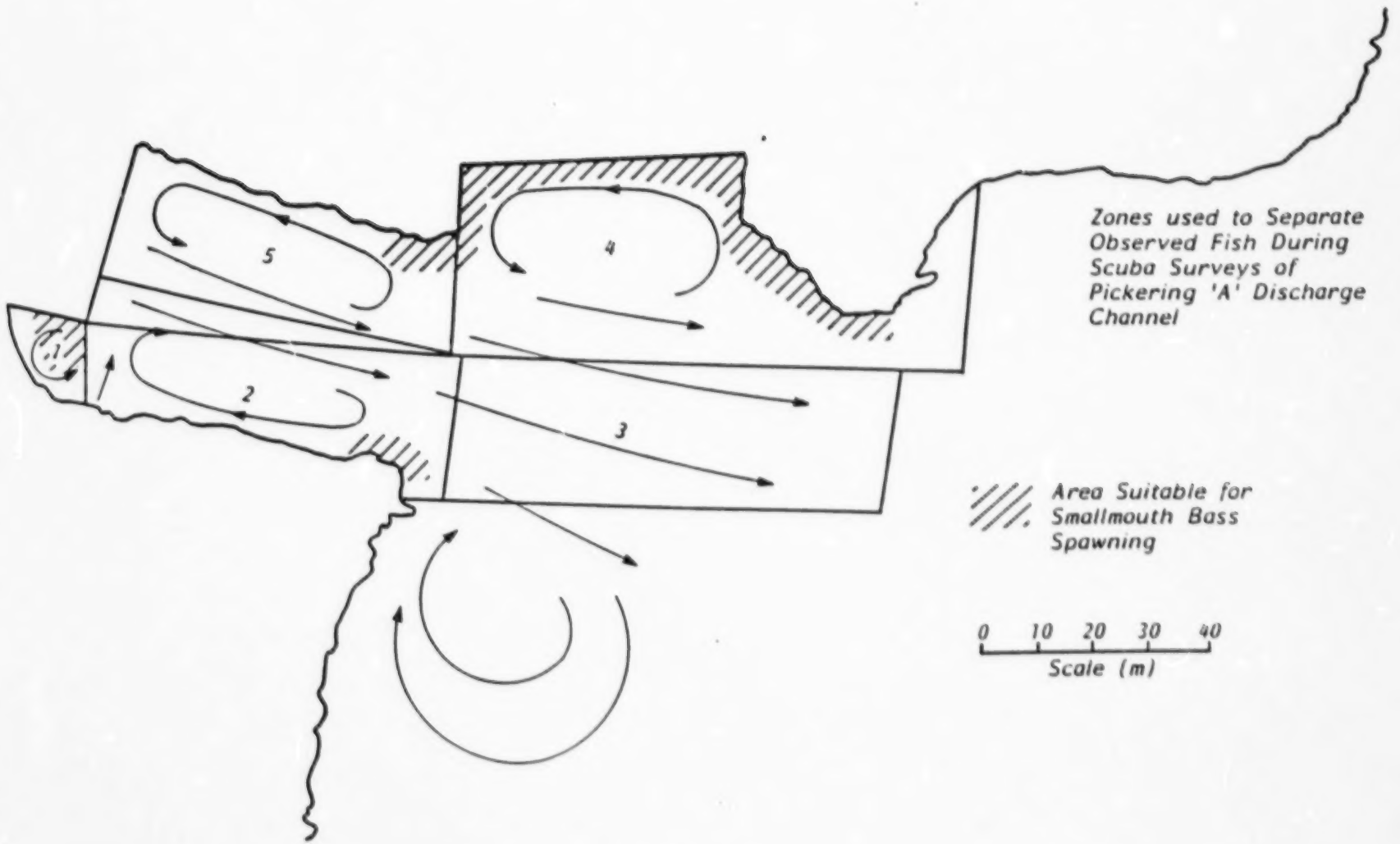

FIGURE 1

PICKERING 'A' DISCHARGE CHANNEL
CURRENT PATTERNS AND FISH
OBSERVATION ZONES

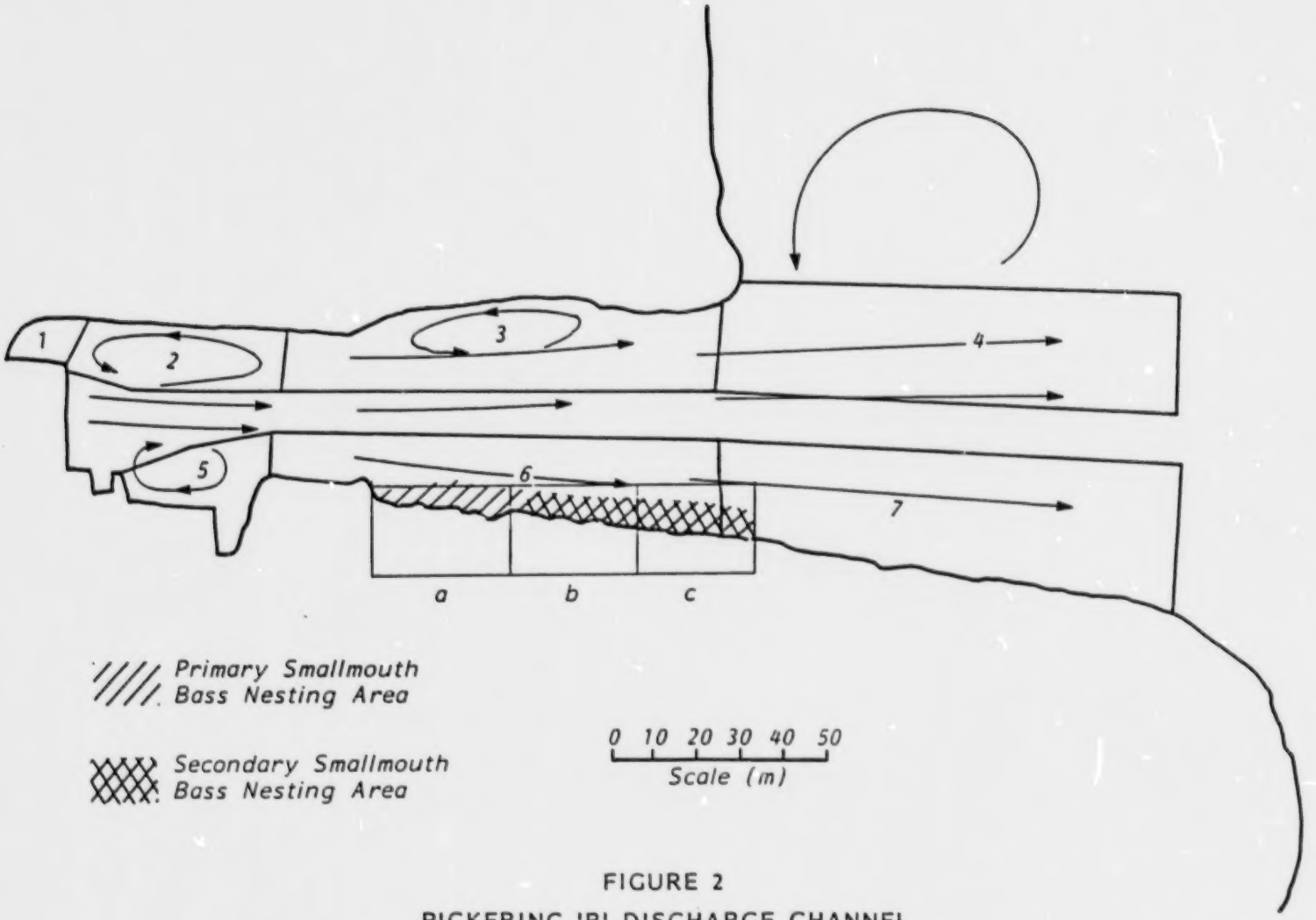

FIGURE 2

PICKERING 'B' DISCHARGE CHANNEL
CURRENT PATTERNS AND
FISH OBSERVATION ZONES

3.2 WATER TEMPERATURE

Condenser cooling water inlet and outlet water temperatures for Pickering NGS A and B are presented in Figures 3 and 4. Inlet temperatures at both stations indicated a gradual rise in water temperature from March through May when they dropped somewhat. Temperatures then increased rapidly through July.

At Pickering NGS A, mean daily delta T's between inlet and outlet temperatures ranged from 5.7°C to 10.8°C for the April to July period. Data were not available for March. Mean monthly delta T's for the April to July period ranged from 6.8°C in April to 9.4°C in June. At Pickering NGS B, mean daily delta T's ranged from 7.2°C to 11.2°C. At this station mean monthly delta T's were quite similar ranging from 9.6°C in May to 10.4°C in June.

On most days inlet temperatures at the two stations were slightly higher than surface water temperatures at a 12 m (depth contour) spar (Geotechnical and Hydraulic Engineering, Design and Development Division of Ontario Hydro, Location THB06) offshore from the Pickering NGS B discharge. This suggests that some recirculation of condenser cooling water occurred on most days. A similar observation was made in the 1987 fish discharge residency report (Ontario Hydro Research Division Report No 88-267-K).

3.3 SUBSTRATE

The substrate in the Pickering NGS A and B discharges was similar to that observed during the 1987 fish discharge residency study.

Pickering NGS A

As in 1987, the substrate along the sides in zones 1, 2 and 5 in the Pickering NGS A discharge channel consisted mainly of cobble with some boulders (Figure 5). In the centre of the channel, the bottom was composed of cobble and boulder embedded in clay. Zone 3 consisted of sand and gravel except at its western limit where a clay bank was found. The substrate in zone 4 consisted of sand with boulder along the side at the outer end of the zone. Once again, attached algae was observed on the boulder along the shoreline from early spring onward.

The cut channel is 15.2 m wide at the immediate station discharge and extends 399 m out into the lake. The length of the channel covered by the dives was approximately 170 m long, starting at the immediate discharge (outfall).

Pickering NGS B Discharge Channel

As in 1987, the substrate in zones 1 and 2 of the Pickering NGS B discharge channel was composed of a mixture of cobble and boulder (Figure 6). In the centre of the channel, in zones 3 and 5, the bottom consisted of boulder and cobble embedded in clay. Along the side at the outer end of zone 5 there was sand with some cobble and boulder. In zone 3 there was a mixture of gravel and sand along the sides with decreasing amounts of gravel towards the centre and into zone 4. This gravel bed extended closer to the centre of the channel

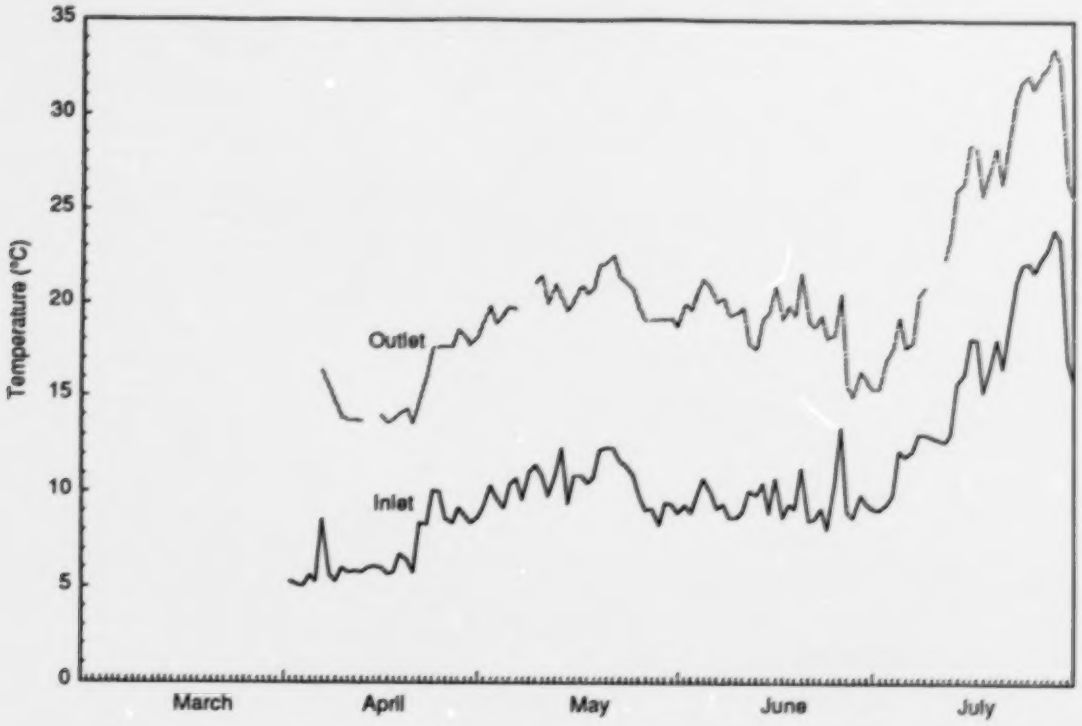

FIGURE 3

PICKERING NGS 'A' - 1988
Inlet and Outlet Temperatures

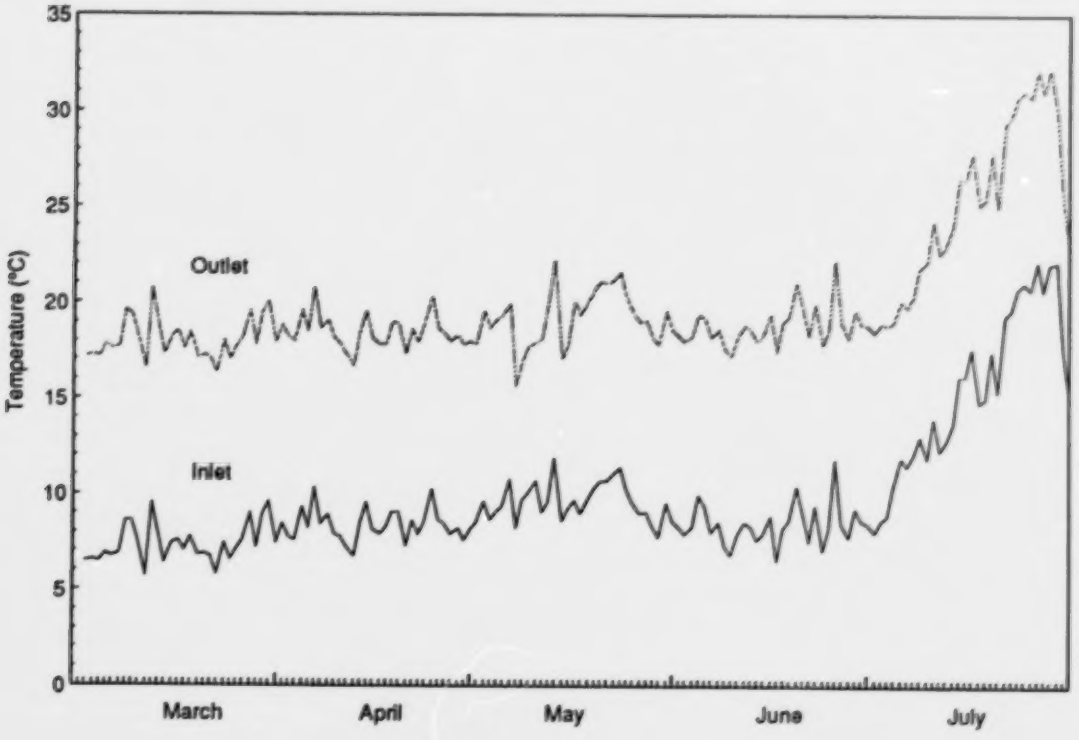

FIGURE 4

PICKERING NGS 'B' - 1988
Inlet and Outlet Temperatures

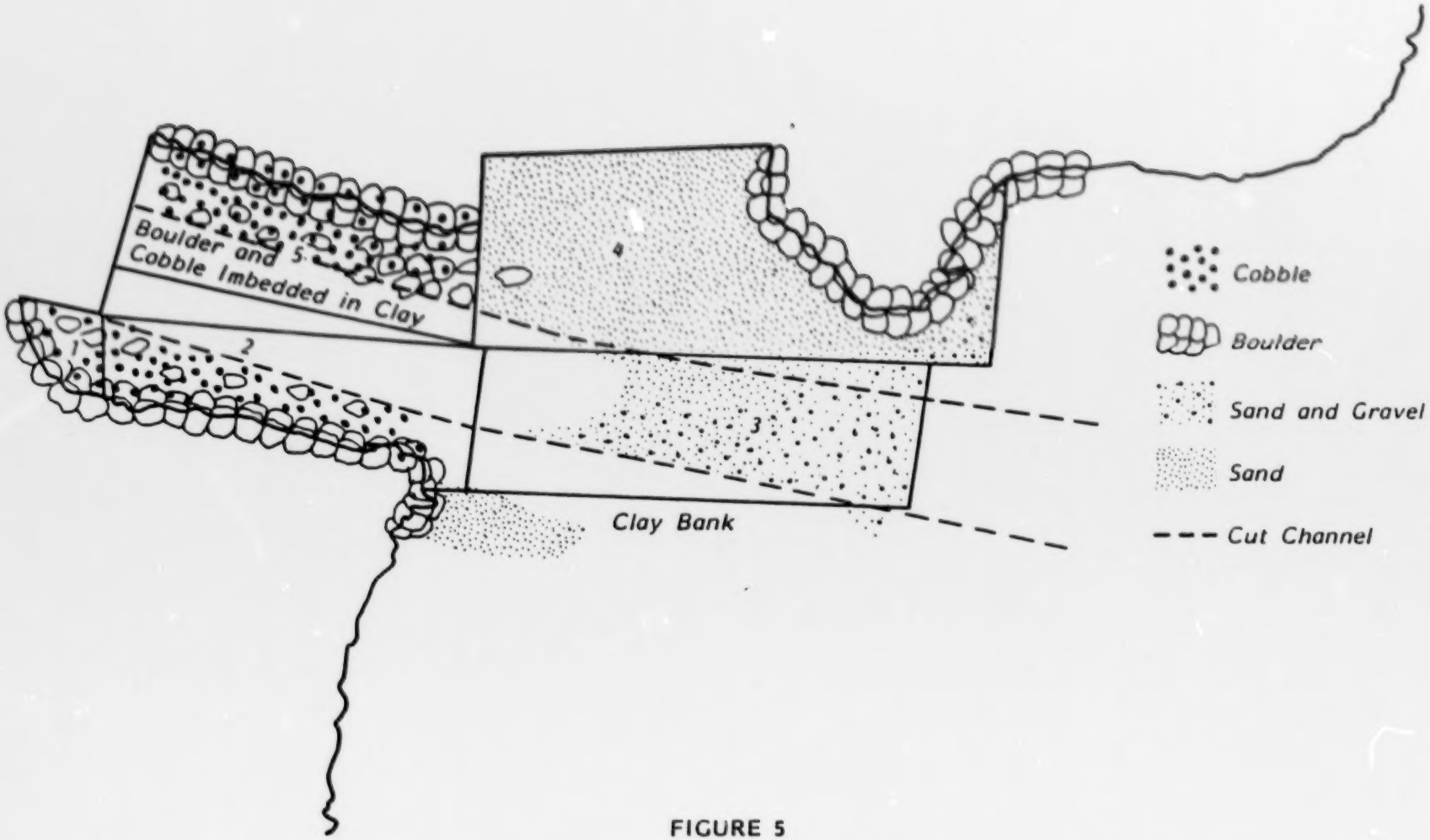

FIGURE 5

DESCRIPTION OF SUBSTRATE IN THE
PICKERING NGS 'A' DISCHARGE CHANNEL

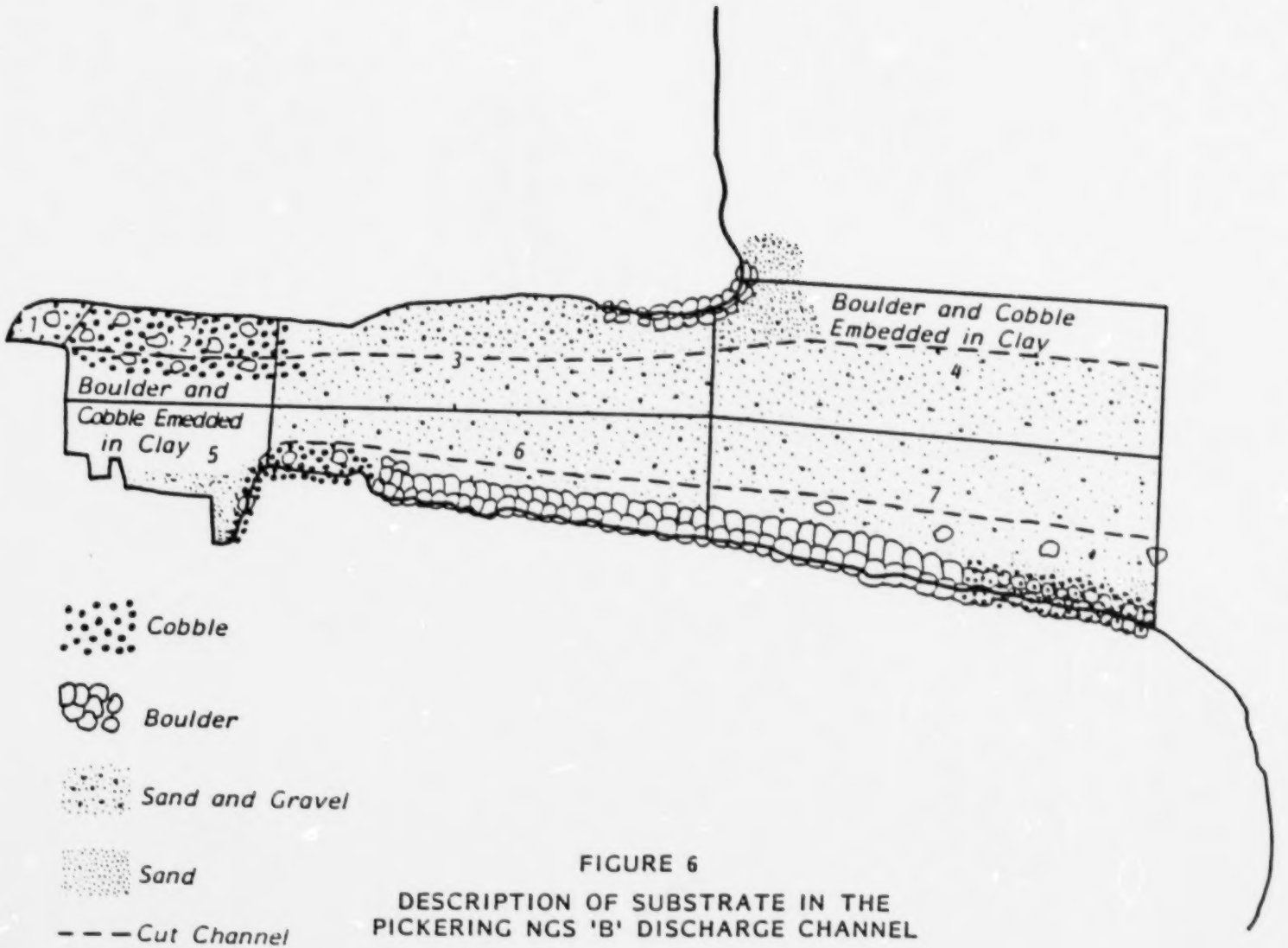

FIGURE 6

DESCRIPTION OF SUBSTRATE IN THE
PICKERING NGS 'B' DISCHARGE CHANNEL

than it did in 1987. Along the east side, at the end of the channel, the substrate consisted of boulder and cobble. Along the west side of the channel in zones 6 and 7 there was boulder with an increasing amount of cobble towards the end of the channel. As in the previous year, attached algae proliferated on the cobble and boulder along the shoreline from early spring on.

The width of the cut channel in the Pickering NGS B discharge is 15.2 m and its length is 430 m. Dives were made to a distance of about 260 m out from the immediate station discharge (outfall) as they were in 1987.

3.4 WATER CURRENT

The descriptions of the water currents in the Pickering NGS A and B discharge channels are general and limited to predominant currents. As with the substrate, the predominant currents in the two discharges were similar to what they were in 1987.

Pickering NGS A Discharge Channel

In the Pickering NGS A discharge, lateral eddy currents persisted in the upper half of the water column along the sides of the channel in zones 2, 5 and 4 (Figure 1). In the centre of the channel and along the bottom, the current was strong and flowed straight out towards the open lake. In zone 3, the predominant current direction throughout the water column was straight out towards the open lake.

Pickering NGS B Discharge Channel

In the Pickering NGS B discharge, eddy currents prevailed in the upper half of the water column along the sides in the areas close to the immediate discharge in zones 2, 3, and 5 (Figure 2). Along the centre and bottom, strong currents flowed straight out towards the open lake. In zone 4 and the area beyond the immediate shoreline in zones 6 and 7, the predominant current direction throughout the water column was also straight out towards the open lake. Calmer water prevailed along shore in zones 6 and 7.

3.5 DISCHARGE RESIDENCE OF FISH

3.5.1 SCUBA Diver's Observation

Complete diver observations, reported as numbers of fish observed in each zone, are presented in Appendix 1 for Pickering NGS A and in Appendix 2 for Pickering NGS B.

Pickering NGS A

Diver estimates of fish numbers in the Pickering NGS A discharge are summarized in Table 1. Fish belonging to 25 species were observed in the Pickering NGS A discharge over the eight dives made between March 22 and June 21, 1988. Rainbow smelt, observed in 1987 was not observed in 1988, while longnose sucker, largemouth bass, sculpin, pumpkinseed, and rainbow trout were observed in 1988 and not in 1987.

TABLE 1

DIVER ESTIMATES OF THE NUMBERS OF FISH PRESENT IN THE PICKERING NGS A DISCHARGE
PICKERING NGS B POSTOPERATIONAL STUDY - YEAR III, 1988

	March 22	April 12	May 4	May 25	June 2	June 9	June 17	June 21	TOTAL
Alewife					400		200	2225	2825
White Sucker	4	26	70	164	304	209	507	219	1503
Carp	336	62	180	82	41	51	54	31	837
Gizzard Shad	8	2	20	54					84
Smallmouth Bass	22	11	35	62	25	24	31	28	238
Brown Bullhead		15	1	8					24
White Bass	1	20	124	230	176	175		47	773
White Perch	51					2	207	25	285
Freshwater Drum	7	4	17	10	14			1	53
Yellow Perch			4	49	3	1	11	5	73
Walleye	8	13	18	17	14	3	1	1	75
Log Perch		2	4						6
Rock Bass				6		1	1	2	10
American Eel		1		1		4		1	7
Channel Catfish		1		1		1		1	4
Lamprey								1	1
Black Crappie				1					1
Northern Pike								1	1
Goldfish	1								1
Longnose sucker				33	629	1		1	664
Largemouth bass				1	1				2
Sculpin				1					1
Pumpkinseed							2		2
Salmonid							1		1
Rainbow trout							1		1
TOTAL	438	157	473	720	1607	472	1016	2589	7472

White sucker, carp, smallmouth bass, white bass, yellow perch and walleye were present on all or most diving occasions. Carp was the most common species observed from March 22 through May 4 and white bass was the most common species present on May 25. Longnose sucker was the most abundant species present on June 2, and white sucker was the most abundant on the following two dives. Alewife was the most common species present on the last observation date, June 21.

Species commonly observed in the Pickering NGS A discharge during the 1988 fish discharge residency study that were not taken in the May to November gill net catches at the Pickering NGS A 3 and 12 m locations were smallmouth bass and walleye. Longnose sucker, which were present in large numbers on June 2, were seldom caught during the 1986 - 1988 Pickering NGS B postoperational fish surveys. Log perch, American eel, channel catfish, lamprey, black crappie and goldfish, which were observed in low numbers in the Pickering NGS A discharge in the present study, were not caught during the May to November fish survey (Ontario Hydro Research Division Report No 89-149-K).

Only one salmonid (unidentified) was observed in the discharge over the study period. Lake trout and brown trout were taken regularly in monthly (May-November) gill net sets at the Pickering NGS A 3 m depth, while rainbow trout were taken occasionally (Ontario Hydro Research Division Report No 89-149-K). Results of a radiotelemetry study conducted on lake trout in 1987 indicated that they are not long-term residents of the thermal plume, but remain in the outer mixing zone of the thermal plume for short periods (Ontario Hydro Research Division Report in draft 1989).

Pickering NGS B

Estimates of fish present in the Pickering NGS B discharge are presented in Table 2. Fish belonging to 23 species were observed over the 10 dives made in the Pickering NGS B discharge between March 22 and June 28. Coho salmon, observed in 1987, was not observed in 1988. Brown trout, rainbow trout, largemouth bass and longnose sucker observed during the present study were not observed in 1987.

White sucker, carp, gizzard shad, smallmouth bass, white bass, freshwater drum, walleye, American eel and rock bass were present on most diving occasions. Carp was the most abundant species present during dives made between March 22 and June 14, and alewife was the most abundant on the remaining two diving occasions.

Although walleye, rock bass and American eel were commonly observed during the discharge dives, they were only taken in very low numbers during the 1988 May to November fish survey (Ontario Hydro Research Division Report 89-149-K). Species that were observed sporadically during the dives that were not taken during the regular fish survey were pumpkinseed, channel catfish, black crappie, northern pike and goldfish.

TABLE 2

DIVER ESTIMATES OF THE NUMBERS OF FISH PRESENT IN THE PICKERING NGS B DISCHARGE
PICKERING NGS B POSTOPERATIONAL STUDY - YEAR III, 1988

	Mar 22	Apr 12	May 4	May 11*	May 24	May 31	June 9	June 14	June 21	June 28**	TOTAL
Alewife									1770	4420	6190
White Sucker	19	9	33	72	37	51	149	1770	105	29	2274
Carp	894	356	335	197	286	172	264	238	248	59	3049
Gizzard Shad	43	255	9	3			55	5	3		373
Smallmouth Bass	67	29	36	24	41	28	81	106	48	1	461
Brown Bullhead	1	1			20						22
White Bass	42	2	1	23	27	26	6	36	72	78	313
White Perch	14					9			1		24
Freshwater Drum	26	10	16	17	3	3	14	13	26		128
Yellow Perch		1		6	1	9		6	5		28
Brown Trout						20					20
Lake Trout		1									1
Brown Bullhead	1	1			20						22
Walleye	46	39	25	1	13	10	16	7	15		172
Rainbow Trout		1									1
Rock Bass		1		4	5		8	10	8	1	37
Pumpkinseed				2		1		3	7		13
American Eel	1		4	5	5	16	8	15	2	7	63
Channel Catfish											0
Lamprey											0
Black Crappie				1							1
Northern Pike				1							1
Goldfish	1				1	1					3
Largemouth bass						2					2
Longnose sucker							7	2			9
TOTAL	1155	706	459	356	459	348	608	2211	2310	4595	13207

* ZONE 4 NOT SURVEYED
** ZONE 3 AND 4 NOT SURVEYED

The attraction of game fish such as smallmouth bass, white bass and walleye to the discharges probably increases their vulnerability to anglers. This is reflected in the higher use of the discharge by anglers relative to other locations in the area (Pope 1989 in draft).

Smallmouth bass (*Micropterus dolomieui*)

Pickering NGS A

Smallmouth bass were present in the Pickering NGS A discharge during all 1988 dives (Table 1). The largest number of smallmouth bass were observed in late May when 62 individuals were counted. The occurrence of maximum numbers of smallmouth bass in the Pickering NGS A discharge was during their customary spawning period of May-June (Scott and Crossman 1973) and was associated with spawning.

A detailed examination of the spatial distribution of smallmouth bass in the Pickering NGS A discharge is presented in Table 3. Generally, they were spread out along the slope on both the east and west sides of the discharge in zones 1, 2, 4 and 5 as they were in 1987.

During late May and early June, when spawning activity was at its peak, the greatest numbers of smallmouth bass were observed in zones 2 and 4. A similar observation was made in 1987. Zones 2 and 4 (Figure 1) were identified as having suitable substrate for nesting (Scott and Crossman 1973).

Considerably more nesting activity was noted in the Pickering NGS A discharge in 1988 than in 1987. One nesting attempt (cleared) observed in zone 1 on May 4, was found abandoned on May 25. An active nest observed in zone 4, just beyond the southern confines of the former barge docking area, on June 2, contained eggs on June 9. However, on June 17, the nest was found abandoned and devoid of eggs. Two additional nest attempts were observed within the confines of the former barge docking area, along the north and east sides, during the same observation period. Further nest clearing attempts (2) were noted within the same area on June 21.

Again, as in 1987, no successful nests were observed in the Pickering NGS A discharge. This lack of nesting success is probably the result of a number of factors, including water depth and shoreline orientation, that would contribute to physical disturbances of guarding males and eggs and/or fry in the nest. Concentrations of predatory (white bass, yellow perch) and scavenging species (white sucker, longnose sucker, carp) were often high within the area where nesting attempts were made and may also have contributed to the lack of successful spawning.

Temperature fluctuations within the discharge channel were minimal during both May and June, 1988 (Table 4). Daily mean temperatures for May and June (to June 21) ranged from 18.7-22.5°C and 17.5-21.5°C, respectively, with maximum and minimum temperatures of 25.9°C and 16.2°C for the time period. Smallmouth bass spawning normally takes place within a temperature range of 15-25 °C (Shuter et al 1980, Graham and Orth 1986), although they are assumed to be

TABLE 3

PICKERING NGS A DISCHARGE SMALLMOUTH BASS OBSERVATIONS, ZONES 1-5
PICKERING NGS B POST OPERATIONAL STUDY - YEAR III, 1988

AREA	Mar 22	Apr 12	May 4	May 25	June 2	June 9	June 17	June 21
1	3	4	1	10		9	1	
2	5	4	14	17	9		7	4
3	4			2			2	1
4	5	2	8	24	14	9	6	13
5	5	1	12	9	2	6	15	10
TOTAL	22	11	35	62	25	24	31	28
VISIBILITY (M)	1.5	2.3	1	1.5-2	2-2.5	3	3	3
TEMPERATURE (°C)		17.5	16.8	16.8	14.2	16.2	15.4	17.4

TABLE 4

MINIMUM, MAXIMUM AND MEAN DAILY TEMPERATURES (°C)
AT THE PICKERING NGS A DISCHARGE IN MAY AND JUNE, 1988

	MAY			JUNE		
DAY	MIN TEMP	MAX TEMP	MEAN TEMP	MIN TEMP	MAX TEMP	MEAN TEMP
1	-	-	-	18.6	21.7	19.9
2	17.9	21.3	19.7	18.4	21.4	19.6
3	17.3	20.9	18.9	18.5	22.9	20.5
4	-	-	-	19.9	23.4	21.2
5	17.3	22.4	19.7	19.5	22.5	20.7
6	18.6	21.1	19.6	19.3	20.7	20
7	-	-	-	19.5	21.2	20.2
8	-	-	-	18.4	21.1	19.3
9	19.7	21.6	21	18.6	20	19.4
10	20.8	22.5	21.4	19	20.2	19.7
11	19.2	20.9	19.9	16.6	19.7	17.8
12	18.9	23.1	20.9	16.2	19.5	17.5
13	-	-	-	16.7	23.5	19.1
14	17.9	20.2	19.5	17.9	21.2	19.4
15	-	-	-	20	21.9	20.8
16	19.5	22.7	20.8	18.2	20	19.1
17	19.6	21.7	20.4	17.2	23.7	19.8
18	19.6	22.3	20.7	17.8	21	19.3
19	20.7	22.6	21.9	18	25.9	21.5
20	21	23.2	22.1	17.6	20.3	19
21	20.8	24.5	22.5	17.2	20.8	18.7
22	20.8	22.8	21.3	18.2	23.2	19.3
23	19.8	25.1	21.1	16.8	19.4	18.1
24	19.3	23.5	20.6	16.6	21.3	18.3
25	18.9	20.3	19.6	17	23.8	20.4
26	17.8	20.9	19	14.1	17.1	15.6
27	-	-	-	12.7	19.5	15
28	-	-	-	14	18.1	16.4
29	-	-	-	14.3	17.1	15.8
30	17.9	20.3	19.1	13.8	16.2	15.4
31	17.6	21.2	18.7			

capable of spawning at temperatures up to 27°C. Thus the temperatures in the Pickering NGS A discharge were suitable for smallmouth bass spawning and were not considered to limit spawning activity.

Pickering NGS B

Smallmouth bass were more abundant in the Pickering NGS B discharge than in the Pickering NGS A discharge. They were present during all dives and occurred in maximum numbers in mid-June when 106 were counted. The period of maximum abudance in the Pickering NGS B discharge was associated with spawning.

The number of smallmouth bass within each zone of the discharge channel during each dive, as well as visibility and water temperature are presented in Table 5.

From March through early-May, smallmouth bass were mainly found in zone 4, at the end of the east side of the channel where mixing of discharge and lake water occurs. In May and June there was movement of smallmouth bass to the west side of the discharge where they were concentrated in zones 6 and 7 preparing for nest building. Even when this staging for nesting had begun, there was still a proportion of smallmouth bass that remained in the mixing zone in area 4.

At the end of May, the concentration of smallmouth bass was mainly in zone 6 and by early June they had spread into zone 7. By the end of June, most of the smallmouth bass had cleared out of zone 6 and a large portion were found in zone 7. A portion of the smallmouth bass were present in the mixing area in zone 4 throughout the study period.

In 1987, smallmouth bass were also concentrated in zone 4 prior to their spawning period, with a few individuals remaining in the area during the spawning period. Smallmouth bass may utilize this area of the discharge for staging and/or feeding prior to spawning. A line of convergence, created along the eastern margin of the discharge, where the discharge current entrains static lake water, could be the main attraction of smallmouth bass to this area. Forage fish, resident in shallow waters east of the discharge could be attracted or brought to this area by the circulation patterns (Figure 2) providing a source of food for foraging smallmouth bass. Beach seines conducted along this shoreline in May and June of 1987 and 1988, indicated that alewife, rainbow smelt and emerald shiner were the most common species present (Ontario Hydro Research Division No 88-267-K and Report in draft 1989), any of which would be acceptable to smallmouth bass.

Nesting activity was once again evident along the west side of the discharge channel in zones 6 and 7, the areas identified as primary and secondary spawning areas in 1987 (Figure 2). Two possible nest sites were first observed on the May 24th dive and intensive surveys of probable spawning areas were initiated on May 25. The results of diver observations are presented by individual nest in Appendix 3 and are summarized in Table 6. Figures 7, 8 and 9 present detailed diagrams of the primary and secondary spawning areas (areas

TABLE 5

PICKERING NGS B DISCHARGE SMALLMOUTH BASS OBSERVATIONS, ZONES 1-7

AREA	Mar 22	Apr 12	May 4	May 11	May 24	May 31	June 9	June 14	June 21	June 28
1	7	1	1	1	5		1			
2	13	1	1			4				
3	12	1	2				5			NS
4	15	10	13	1	9	7	16	38	7	NS
5	8	4	8		5	3	3	2	1	
6	10	9	6	7	22	11	29	42	11	1
7	2	3	5	15		3	27	24	29	NS
TOTAL	67	29	36	24	41	28	8	106	48	1
VISIBILITY (M)	1.5	3	1-1.5	1.5	2	1.5-2	3		3	3-<1
TEMPERATURE (°C)	18	16	188	18.2	19.3	18.6	16.7	18	17.5	

TABLE 6
SMALLMOUTH BASS NESTING ACTIVITY, PICKERING NGS B DISCHARGE, 1988

NEST DEVELOPMENT CODE	MAY 25	MAY 27	MAY 30	JUNE 1	JUNE 3	JUNE 6	JUNE 8	JUNE 10	JUNE 13	JUNE 15	JUNE 17	JUNE 20	JUNE 23	JUNE 27	JUNE 29	JULY 4	JULY 7
0-NEST DEPRESSION NO EGGS	9	14	9	11	12	10	7	9	3	6	7	4				1	2
1-WITH EGGS	1	1	5	2					5	1			1			1	1
2-TRANSPARENT OIL DROPLET FRY				1													
3-GREY-BLACK FRY UNRISEN			2														
4-BLACK FRY UNRISEN		1		1													
6-SOME BLACK FRY (<50% RISEN)			1	2	2												
8-MOSTLY BLACK FRY (>50% RISEN)			1	2	4	6	6	3	2	1							
9-RISEN GREEN FRY											1	1	1				
X-NEST ABANDONED OR DESTROYED			1	2	2	2	3	2	5	3		3	4	1			
ACTIVE NESTS	1	2	9	8	6	6	6	3	7	2	1	1	2			1	1
TOTAL NUMER OF	10	16	18	19	18	16	13	12	10	8	8	5	2			2	3

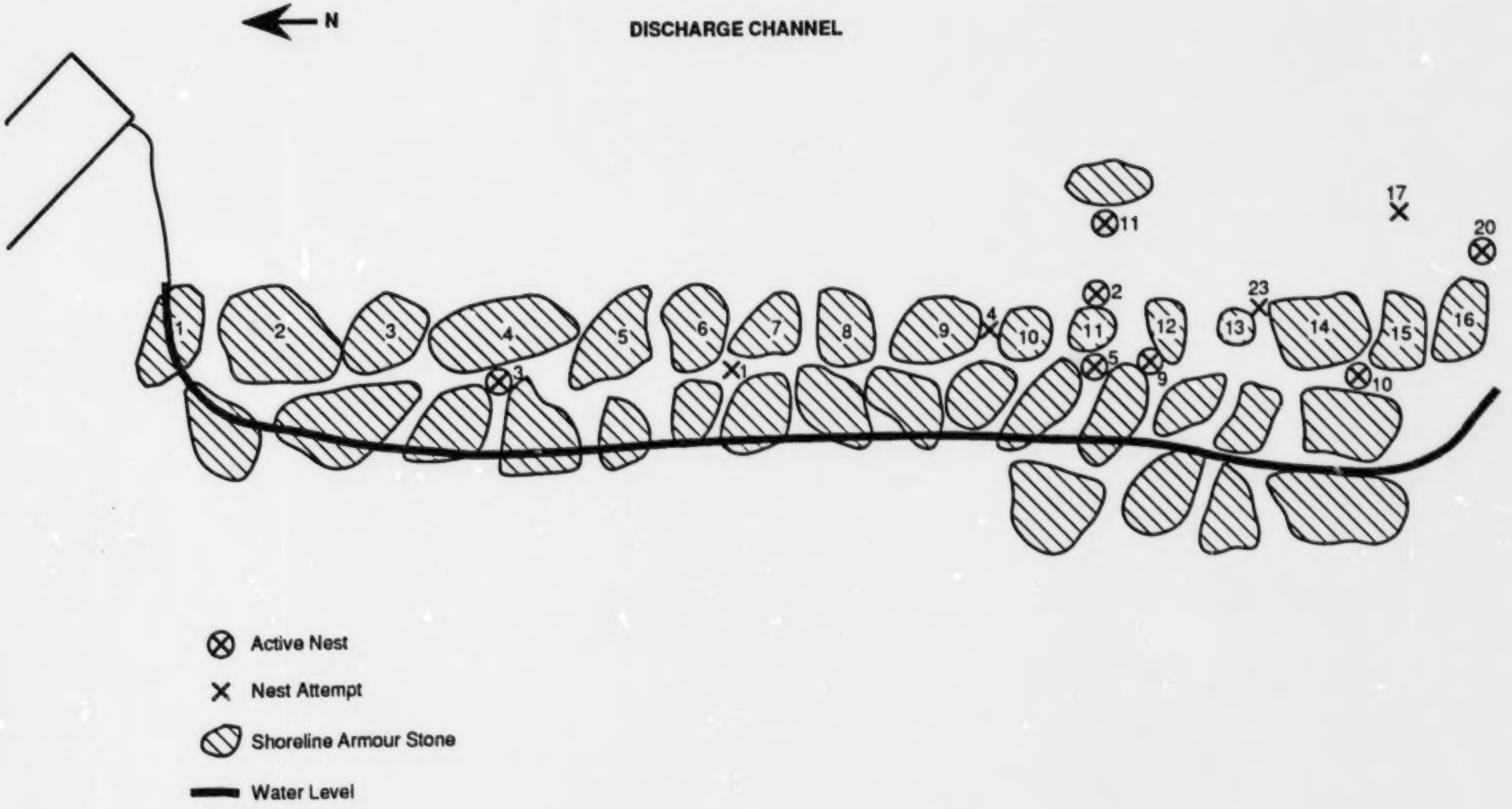

FIGURE 7
PRIMARY BASS NESTING AREA (AREA A)
PICKERING NGS 'B' DISCHARGE

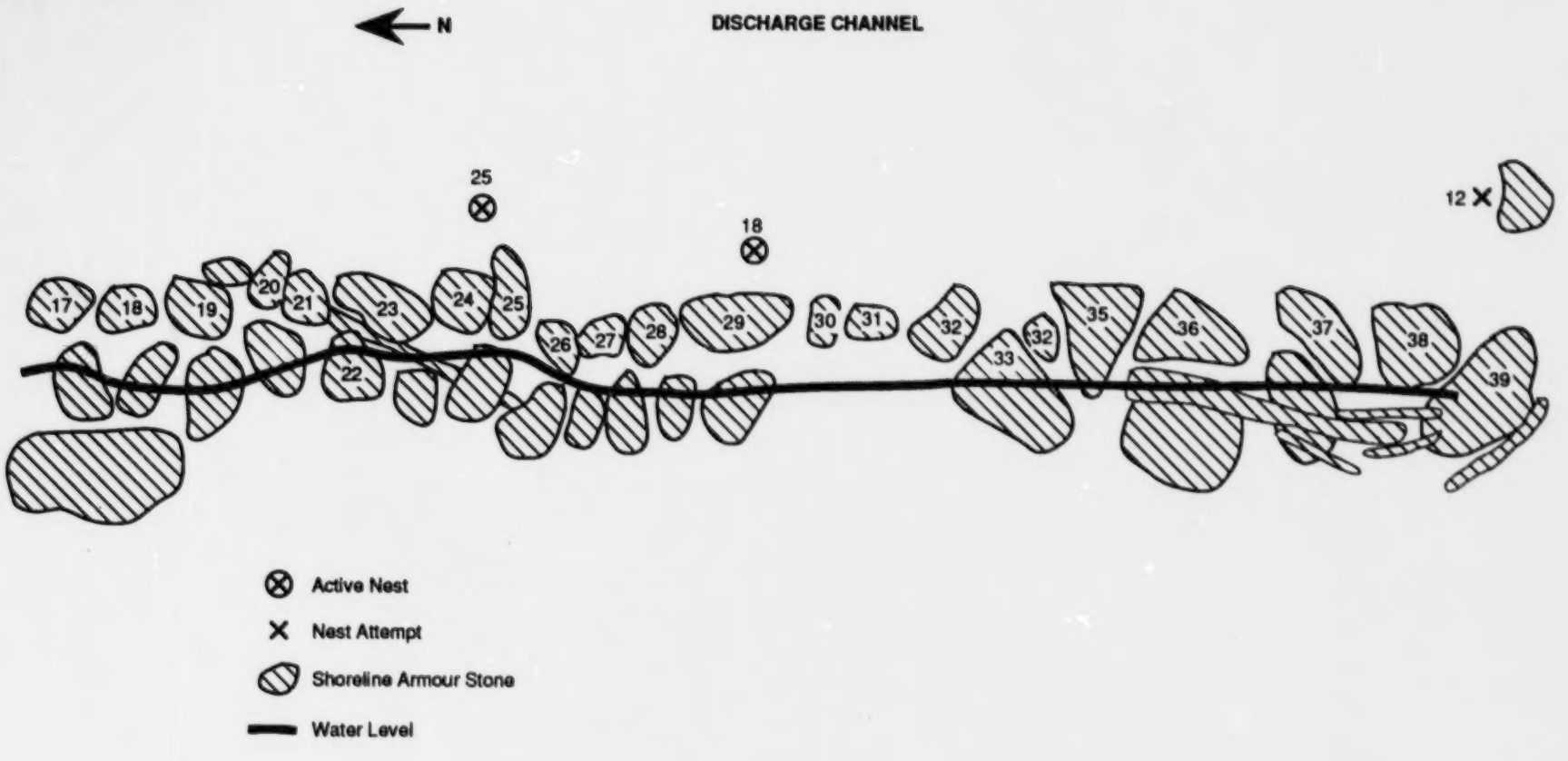

FIGURE 8
SECONDARY BASS NESTING AREA (AREA B)
PICKERING 'B' DISCHARGE

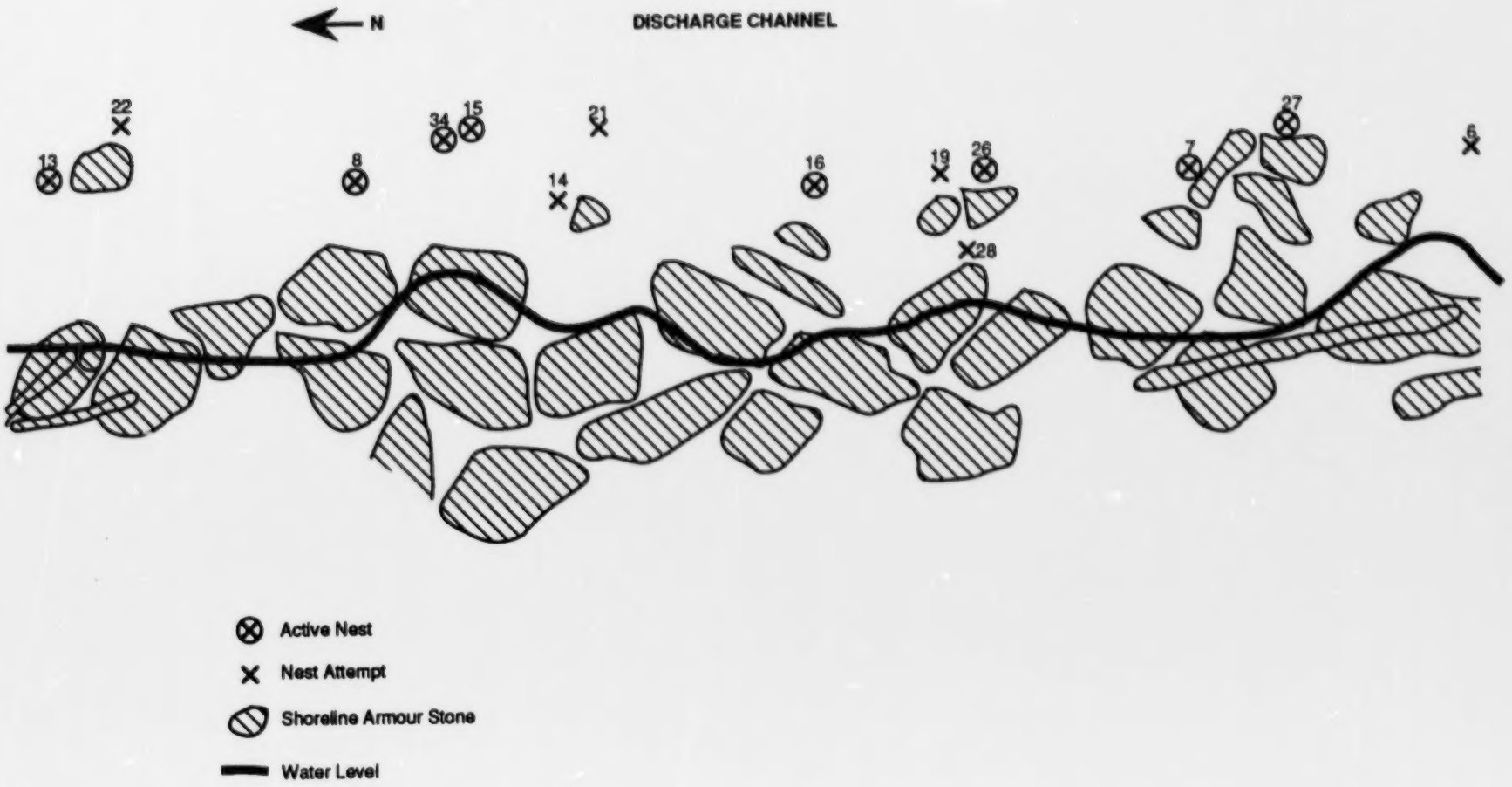

FIGURE 9
SECONDARY BASS NESTING AREA (AREA C)
PICKERING 'B' DISCHARGE

a, b and c, respectively, in Figure 2 and show the location of individual nests. These figures show that the majority of nesting activity was located in the southern half of both the primary and secondary spawning areas.

Examination of Table 6 suggests that nesting activity was in progress on the earliest observation date, May 25 and continued to July 11. Total number of active nests (containing eggs or fry) located during peak spawning activity (May 30) was 9, although a total of 34 nesting attempts and 20 active nests were observed over the study period.

Two distinct waves of major spawning activity ($\geq$ 5 nests with eggs) were apparent within this time frame, with nests receiving eggs between May 25 and June 1, 13 and 15, and some late attempts on June 23, and July 4 and 7. The first wave of activity was almost equally split between the primary and secondary spawning areas, with six and five nests, respectively, receiving eggs. The second wave of spawning activity probably took place as a result of the failure or loss of previous broods, with the majority of activity occurring further south, within the secondary spawning area. Further attempts were noted near the southern limit of the discharge shoreline on June 23, and July 4 and 7. Of these spawning periods, only those nests that received eggs during the first period developed past the egg stage. Nests that contained eggs from the latter two spawning events had either been abandoned by the guarding male on subsequent dives (2 of 6 in mid June) or the eggs were absent while the male was still present. The eggs in these nests may have been removed by scavengers which were present in large numbers.

Of the nine active nests observed during the first spawning period, six progressed to the black risen fry stage, but only one was observed to develop to the green fry stage (Table 6). Fry in the remaining nests disappeared between June 8 and June 13.

Examination of temperature records for this time period showed no major fluctuations that would account for male desertion or larval mortality. Maximum, minimum and daily mean temperatures for this time period (Table 7) were 21.7, 16.4 and 17.2-19.4°C. These temperatures are considered acceptable for guarding males and survival of fry (Shuter et al 1980, Vogele 1982). Beyond mid-June, temperatures remained below 25°C and in most cases below 20°C until mid-July. Thus high temperatures were not considered a limiting factor for spawning activity or successful development of fry.

Development rate at individual nests varied from 7-9 days (eggs to risen fry) at nests 9 and 10, to 12 days at nest 2. Nests 5 and 15 were not located until active fry were visible. A pair of adults present at nest 8 on May 25, probably represented the start of this nest. Black risen fry were present by June 1, indicating a spawn to rise period of 7 days.

Predictions of spawn to hatch and hatch to rise times for Baie du Dore smallmouth bass were presented by Shuter et al (1980). The daily mean temperature at Pickering NGS B between May 25 and June 1 ranged from 17.8 to 19.5°C. At an ambient temperature of 19°C eggs would be expected to hatch in 4 days and fry to rise from nests to become free swimming in an additional 6 days, for a total of 10 days. Actual field data, however, indicate a considerable scatter of data points in the 18-20°C range. This suggests that

TABLE 7

MINIMUM, MAXIMUM AND MEAN DAILY TEMPERATURES (°C)
AT THE PICKERING NGS B DISCHARGE IN MAY, JUNE AND JULY, 1988

	MAY			JUNE			JULY		
DAY	MIN TEMP	MAX TEMP	MEAN TEMP	MIN TEMP	MAX TEMP	MEAN TEMP	MIN TEMP	MAX TEMP	MEAN TEMP
1	16.6	19.8	17.8	16.9	20.1	18.3	17.8	18.9	18.4
2	18.3	20.9	19.5	16.4	20.5	18.0	18.0	19.9	18.9
3	17.3	20.3	18.7	16.9	19.7	18.3	17.3	21.0	18.8
4	17.4	23.1	19.1	18.0	22.1	19.4	17.3	20.1	19.0
5	17.0	21.3	19.3	17.7	21.0	19.2	19.0	21.6	20.1
6	15.8	23.7	19.9	17.6	18.8	18.2	18.6	21.3	19.8
7	14.0	17.4	15.6	17.8	19.5	18.6	18.6	22.5	20.3
8	15.6	18.2	16.9	16.6	19.6	17.6	19.7	24.5	21.8
9	16.0	18.4	17.7	16.4	18.0	17.2	20.3	26.8	22.1
10	16.0	19.9	17.9	17.2	19.2	18.1	20.8	29.1	24.2
11	15.9	20.4	18.1	17.5	20.8	18.8	21.1	23.8	22.6
12	18.4	21.8	19.9	17.3	20.5	18.6	22.0	25.2	23.0
13	16.3	25.5	22.2	16.8	21.7	18.0	21.6	27.3	24.1
14	15.8	18.9	17.0	16.7	20.4	18.3	23.0	28.6	26.5
15	15.8	20.4	17.8	17.0	21.9	19.4	22.2	30.4	26.4
16	19.1	21.0	20.1	17.0	18.6	17.4	23.8	31.5	27.7
17	18.7	20.5	19.4	16.9	23.8	19.0	23.5	26.8	25.1
18	18.9	22.0	20.1	18.0	21.5	19.3	23.3	27.4	25.4
19	19.3	21.6	20.6	19.0	25.5	21.0	25.0	29.8	27.7
20	20.7	21.8	21.1	17.0	21.7	19.7	22.5	26.9	24.9
21	20.2	22.2	21.0	16.8	20.7	18.3	26.5	31.4	29.4
22	20.5	22.7	21.2	18.0	23.5	19.9	27.7	32.6	29.8
23	19.5	26.0	21.6	16.8	19.6	17.8	28.5	32.5	30.8
24	18.9	23.4	20.2	16.2	21.4	18.6	29.8	32.6	31.0
25	18.8	20.0	19.5	20.3	25.1	22.2	29.1	33.9	30.7
26	17.1	21.8	19.0	17.7	21.4	19.0	30.4	34.5	32.1
27	17.7	22.4	19.1	17.2	19.1	18.1	29.3	33.1	30.9
28	17.3	20.0	18.2	18.0	21.7	19.6	30.3	34.2	32.2
29	17.0	19.2	17.8	17.5	20.1	18.9	26.9	32.3	29.9
30	17.3	21.0	19.5	18.1	19.7	18.8	23.1	27.6	25.3
31	16.8	21.3	18.6				21.6	26.0	23.1

hatch times from 4 to 8 days are possible, resulting in total development times of 8 to 12 days from spawn to risen fry. Vogele (1982) found that fry took six days between hatch and swim-up in an Arkansas lake (Bull Shoals Lake) at temperatures between 18.3 and 21.1°C. Thus, development rates of 8 to 12 days in the Pickering NGS B discharge are comparable to times presented by other authors.

A comparison of 1987 and 1988 results indicate that initial spawning took place earlier in 1988 than in 1987. Eggs were not observed until June 3 in 1987. In 1988 risen fry were observed on June 5, which indicates that first spawning took place about 10 days earlier on May 26 (Shuter et al 1980, Ontario Hydro Research Division Report No 88-267-K).

In 1988, eggs were first observed on May 25, which agrees well with the 1987 results. However, back calculations using the date on which risen black fry were first observed, indicate that spawning and hatching took place as early as May 20 and 24, respectively. This is approximately 1 week earlier than in 1987. Earlier spawning in 1988 is also supported by the period when peak number of nests containing stage 8 fry (black risen) were present. In 1987, this peak occurred between June 12-18, while in 1988 it occurred between June 6 and 8. Thus it appears that spawning was earlier in 1988 than 1987, but still within the normal spawning period for smallmouth bass in Ontario (Scott and Crossman 1973).

Larvae collected from nests 8, 9, 10 and 15 on June 3 and 6 (Table 8) ranged in length from 11.0 to 15.1 mm. Within approximately 1 week (Table 9), these nests were deserted, and all fry were missing. Generally, these fry were not large enough to survive on their own, although those from nest 15 (14.8-15.1 mm) were near the size when mobility greatly increases (D. Wismer, personal communication).

De Angelis and Coutant (1979) investigated the growth rate of smallmouth bass at a number of experimental temperatures. At 20.1°C, fry developed from a length of 12 mm to 14 and 16 mm in approximately 5 and 10 days, respectively, resulting in a growth rate of 0.44 mm/day. George and Hadley (1979) however, reported growth rates of 1.15 mm/day from fry collected from natural populations in the upper Niagara River. Assuming fry to be 5-7 mm at hatch (Auer 1982, Table 8), those collected from nests in the Pickering discharge should be 4.5 to 8.0 days post-hatch based on George and Hadley's (1979) study, or 13.5 to 20 days post-hatch based on De Angelis and Coutant's (1979) study. Our results (Table 9, nests 9 and 10) suggest time periods from 4 to 6 days between probable hatch and collection of 11 to 13 mm larvae. Although too few fry were collected for proper verification of growth rate, it would appear that it approximates the rate indicated by George and Handley (1979) rather than the slower rate observed by De Angelis and Coutant (1979).

Generally, 3-4 weeks of parental care is provided following swim-up, during which time fry attain a size of 20-30 mm and can survive independent of the guarding adult (Vogele 1982). Male desertion of the brood appears to be fairly common and often occurs within one week of swim-up (M. Ridgeway, personal communication). This appears to have been the situation for many of the nests in the Pickering NGS B discharge in 1988.

TABLE 8

LENGTHS OF SMALLMOUTH BASS LARVAE COLLECTED
FROM NESTS IN THE PICKERING NGS B DISCHARGE

DATE	NEST	DEVELOPMENT STAGE	LENGTH (MM)
MAY 25	2	YOLK-SAC LARVAE*	7.0
MAY 30	5	LARVAE	11.6
JUNE 3	9	LARVAE	11.0, 13.0
JUNE 6	8	LARVAE	12.4, 12.7
JUNE 6	10	LARVAE	11.2, 11.4, 12.0, 11.6, 11.7
JUNE 6	15	LARVAE	14.8, 15.1, 14.9

* HATCHED AT TIME OF COLLECTION

TABLE 9

DEVELOPMENT OF SMALLMOUTH BASS EGGS AND LARVAE
IN THE PICKERING NGS B DISCHARGE, 1988

	NEST NUMBER											
	2		5		8		9		10		15	
DATE	ADULT CODE	NEST CODE*	ADULT CODE	NEST CODE	ADULT CODE	NEST CODE	ADULT CODE	NEST CODE	ADULT CODE	NEST CODE	ADULT CODE	NEST CODE
MAY 25	1	1	1	+	2	0						
MAY 27	1	1	1	4	-	-	1	0	1	0		
MAY 30	1	3	1	8	1	6	1	1	1	1	1	3
JUNE 1	1	4	1	8	2	8	1	6	1	2	1	6
JUNE 6	1	8	1	8	1	8	1	8	1	6	1	8
JUNE 8	0	8	1	8	1	6	1	8	0	8	0	8
JUNE 10	0	8	1	8	0	-	0	6	1	8	0	-
JUNE 13	1	-	1	8			0	-	1	8		
JUNE 17	0		2	9								
JUNE 20			1	9								
JUNE 23			1	9								

* NEST CODES AS PER TABLE 6
ADULT CODES: 0-NO ADULTS PRESENT
1-MALE PRESENT
2-MALE AND FEMALE PRESENT

+ UNABLE TO OBTAIN ACCURATE OBSERVATIONS

Water levels within the Great Lakes basins have been unusually high in the past 2-3 years. On an annual basis, water levels reach their maximum height in mid- to late- April and recede as the summer progresses (IGLD 1987 and 1988). Water levels in May of 1988 were 24-28 cm lower (min-max levels) than May of 1987. This may have had a significant effect on the success of the bass spawning effort as many of the best sites in the primary spawning area, which were effectively utilized in 1987, were in water which was less than 1 m in depth in 1988. No nests which developed past the egg stage in 1988, were located in water that was less than 1 m deep. This corresponds with minimum nest depths observed by Vogele (1982) in an Arkansas Lake (1.1 m). At the Pickering NGS B discharge, attempts to nest at depths less than 1 m would result in increased risks of predation (birds and anglers) for adults and fry as well as an increased risk of physical disturbance of nesting adults or fry by wave action from storm events or boat wakes. Spawning sites within the secondary spawning area do not provide the same degree of protection from currents and predators as those within the primary spawning area. Hence it appears that the reduction in water depth between 1987 and 1988 may have contributed to the lack of spawning success within the Pickering NGS B discharge channel in 1988.

The results of the 1987 and 1988 discharge residency studies suggest that the presence of the station may result in an increase in the local smallmouth bass population by providing suitable spawning habitat. However, it is not known whether smallmouth bass spawning in the discharges has resulted in recruitment to the population.

Gizzard shad (*Dorosoma cepedianum*)

Gizzard shad were only observed in the Pickering NGS A discharge from March 22 to May 25 with the largest number observed on May 25. In the Pickering NGS B discharge, gizzard shad were present on all but three occasions. The numbers present varied considerably with the largest number of 255 observed on April 12.

In the Pickering NGS A discharge gizzard shad were commonly found in the eddy currents along the east side of the channel in zones 4 and 5. In the Pickering NGS B discharge most of them were found in zones 4 and 7, at the mouth of the discharge channel. In 1987, most of the gizzard shad were found in the eddy currents in zone 4 in the Pickering NGS A discharge and in zones 2 and 3 in the Pickering NGS B discharge. Gizzard shad were also typically found in eddy currents in the Nanticoke TGS discharge (Ontario Hydro Research Division Report No 87-228-K).

In both 1987 and 1988, gizzard shad were never present in very high numbers in either of the discharges. However, the 1988 study, like the 1987 study, was limited to the March-July period. Thus no winter observations were obtained in either year and the low presence of gizzard shad during both studies does not necessarily preclude the possibility of massive impingement of these fish at Pickering NGS.

Gizzard shad have been found to concentrate in areas into which warm waters flow during the winter (Bodola 1966). Their preference for the Pickering NGS A and B discharges was apparent during the 1986 to 1988 Pickering NGS B preoperational and postoperational aquatic studies (Ontario Hydro Research Division Report Nos 84-135-K, 87-194-K, 88-261-K, and 89-149-K).

Massive impingement of gizzard shad during winter has been reported at several Ontario Hydro generating stations (Ontario Hydro Research Division Report No 77-400-K and C78-31-K). Such an event occurred at Pickering NGS A in 1978 during a severe winter storm (Ontario Hydro Research Division Report No 80-226-K) when in excess of 35,000 kg of gizzard shad was impinged. In addition, overwintering of large numbers of gizzard shad in the Pickering NGS A discharge was observed in the winter of 1975-1976 (Ontario Hydro Research Division Report No 80-226-K).

Impingement of gizzard shad had declined considerably between 1978 and 1985, with a yearly total impingement of only 31.3 kg in 1985. In 1986, gizzard shad impingement jumped to 9,800 kg over a two-day period (February 8 and 9, Pope 1988) while no gizzard shad were impinged between January and March of 1987 at Pickering NGS A and only 0.2 kg were impinged at Pickering NGS B (RMEP-IR-07000-16). In 1988, total annual impingement of shad was 276 kg at Pickering NGS A and 389 kg at Pickering NGS B. Thus total annual impingement of gizzard shad fluctuates considerably among years.

Maximum monthly impingement of gizzard shad at Pickering NGS since 1978 has generally occurred either in the winter (December-February) or in the early spring (March-April). Higher impingement in the winter months suggests the concentration of shad in the warmer waters of the thermal plume during winter months, while higher impingement in the spring was probably a result of inshore spawning migration.

Low numbers observed in the discharge during the present study as well as in 1987 do not preclude the possibility of massive impingement of gizzard shad at the Pickering NGS B since the number of winter observations in both years were limited. In addition impingement records of gizzard shad indicate that yearly fluctuation in numbers can be considerable.

Walleye (*Stizostedion vitreum*)

In the Pickering NGS A discharge, walleye were present in low numbers, with higher numbers observed in April and May than in the remaining months. As in 1987, walleye were more common in the Pickering NGS B discharge than in the Pickering NGS A discharge, with largest numbers observed during the first three dives conducted between end-March and early-May. The periods when largest numbers of walleye were present in the discharges coincides with their expected spawning period. Results of a 1988-1989 winter creel survey indicated that walleye are also present in the discharge in winter months preceeding March (Pope 1989 in draft).

At the workshops it was hypothesized that the different orientation of the Pickering NGS B discharge and the large enclosed channel would make this discharge more attractive to walleye than the Pickering NGS A discharge (Greig

et al 1986). The larger numbers of walleye observed in the Pickering NGS B discharge than in the Pickering NGS A discharge, in both 1987 and the present study, appears to support this hypothesis.

Walleye placed themselves close to the bottom just below the strong discharge current in both discharges. In the Pickering NGS A discharge, most of the walleye were found near the immediate discharge in zones 2 and 5. In the Pickering NGS B discharge they were found at the centre of the channel in zones 3, 4, 6 and 7, over sand and gravel substrate, a preferred substrate type for walleye (Kitchell et al 1977). The substrate in these areas includes either bolders, cobble and mixtures of sand and gravel, and are suitable for walleye spawning (Scott and Crossman 1973).

The position of the walleye in the discharge channels in both the 1987 and 1988 studies, demonstrates their association with strong currents, and that, as hypothesized at the scoping workshop(Greig et al 1986), they may be attracted to the discharge by the strong currents.

Although higher numbers of walleye were observed in the discharges during their expected spawning period, no spawning activity was observed during the dives which were confined to the daytime. However, walleye spawning occurs at night (Ryder 1977). Therefore, the lack of visible signs of spawning during the dives does not preclude the possibility that walleye may spawn in the discharges.

Walleye eggs were caught in entrainment samples collected in the intake in 1988. In addition, a walleye juvenile was identified in a stomach of a brown trout collected at the Pickering NGS A 3 m location in March of 1988. These data suggest that walleye spawn in the area of Pickering NGS.

Carp (*Cyprinus carpio*)

Carp were present in the Pickering NGS A and B discharges on all diving occasions and were more common in the Pickering NGS B discharge than the Pickering NGS A discharge. In both discharges largest numbers of carp were observed on the first diving occasion on March 22.

In both 1987 and the present study, carp were mainly found along the sides of the discharge channels, oriented into the current, feeding on algae growing on the boulder and cobble.

White sucker (*Catostomus commersoni*)

The numbers of white sucker in the discharges increased in late-May and June, coincident with their expected inshore spawning migration period (Scott and Crossman 1973). A maximum of 507 white sucker were counted in the Pickering NGS A discharge on June 17 and 1,770 were estimated to be present in the Pickering NGS B discharge on June 14. The white suckers were more abundant in 1988 than in 1987.

May to November gill netting data suggests that white sucker move into the Pickering NGS A discharge to Simcoe Point study area following their customary spawning period (Ontario Hydro Research Division Report 89-149-K).

Freshwater Drum (*Aplodinotus grunniens*)

Low numbers of freshwater drum were observed in both discharges during most dives. In 1987, large numbers (>100) were observed on several occasions in the Pickering NGS B discharge. Maximum numbers observed in 1988 were 26 in the Pickering NGS B discharge.

In both 1987 and 1988, freshwater drum were found swimming along the sides and in the eddy currents. In the Pickering NGS B discharge they were mainly found along the east side of the channel. This species was generally found mixed in with white perch, white bass and gizzard shad. Their presence in the discharges is not surprising since they are inhabitants of the shallow waters (Scott and Crossman 1973).

Alewife (*Alosa pseudoharengus*)

Alewife were first observed in the Pickering NGS A discharge in early-June with the presence of a large school noted on June 21. A surge of alewife into the Pickering NGS B discharge was first observed in late-June. Although alewife entered the Pickering NGS A discharge earlier in the year than the Pickering NGS B discharge, it was not as early as in 1987, when their appearance into the Pickering NGS A discharge in April coincided with their inshore spawning migration (Graham 1957).

Large schools of alewife were concentrated close to the immediate discharges, swimming in back eddies, in zones 1 and 2 in the Pickering NGS A and in zones 1, 2 and 5 in the Pickering NGS B discharge. Graham's (1957) description of the milling and "rollercoaster" movements of the schools aptly describes their swimming pattern in the discharge.

White bass (*Morone chrysops*)

White bass, whose occurrences in the discharges were sporadic in 1987, were present during all but one dive in the Pickering NGS A discharge and during all dives in the Pickering NGS B discharge. They were more common in the Pickering NGS A discharge, as was the case in 1987. The maximum number counted in the Pickering NGS A was 230 on May 25, and in the Pickering NGS B a maximum of 78 were counted on June 28.

This species was actively swimming along the sides of the discharges, at mid-depth, in the eddy currents.

During the Pickering NGS B preoperational (1979-1981) and post-operational studies (1986-1989) white bass were consistently taken in highest numbers in gill nets set at the Pickering NGS A discharge. In some years, this species has demonstrated a preference for the heated discharge waters during the fall (Ontario Hydro Research Division Report No 84-135-K, 87-149-K and 87-194-K). A study on radio-tagged white bass suggested that they remained in the Pickering NGS A discharge for at least several days at a time, rather than entering it diurnally or for brief periods (Ontario Hydro Research Division

Report No C79-3-K). This attraction to the discharge increases the vulnerability of this game fish to anglers (Ontario Hydro Research Division Report No 87-228-K).

A study was conducted in 1977-1978 to identify the food intake and determine the condition of white bass in the Pickering NGS A discharge. White bass was selected for study at that time because it was one of the most abundant of several sport fishes inhabiting the discharge and was the object of anglers at this location (Ontario Hydro Research Division Report No 79-218-K). The data indicated that the food intake of white bass in the discharge as well as the control site was moderate throughout the year. The condition factor of the fish increased from April to November when it was slightly higher than that of fish from a control location.

White Perch (*Morone americana*)

White perch were observed in the Pickering NGS A discharge on the first diving occasion and then not again until June 9. The highest numbers (207) were encountered on June 17. Dense schools observed in the Pickering NGS B discharge in 1987, were not observed during the present study. White perch were present only on three occasions, in low numbers each time. However, with fewer dives conducted in 1988, a less detailed picture of fish discharge residency in the Pickering NGS discharges was obtained for this year and influxes of schools of fish were easily missed.

In the Pickering NGS A discharge, white perch were found mainly in the vicinity of the service water discharge pipe in zone 4 and generally stayed at the periphery of the discharge current in back eddies. In the Pickering NGS B discharge they were found along the east side of the discharge channel along the rip rap in zones 1 and 2, as they were in 1987.

Like white bass, white perch demonstrated a preference for the heated discharge areas in the fall during fish surveys conducted at Pickering NGS in previous years.

Rock bass (*Ambloplites rupestris*)

Rock bass were found sporadically, in very low numbers, in the Pickering NGS A channel and on most occasions, in low numbers, in the Pickering NGS B channel. Largest number observed was 10 in the Pickering NGS B discharge in mid-June.

In the Pickering NGS B discharge they were found along the cobble on the west side of the channel in zones 6 and 7 where they were found building nests in-between the smallmouth bass nests, in late May and early-June.

Yellow perch (*Perca flavescens*)

As in 1987, yellow perch were more common in the Pickering NGS A discharge than in the Pickering NGS B discharge. Again, although frequently present in the Pickering NGS A discharge, they were only found in low numbers. Largest number counted was 49 on May 25. In the Pickering NGS B discharge they were only present sporadically in very low numbers.

Their distribution in the Pickering NGS A discharge was similar to that of 1987, with most found concentrated along the sides in zone 4 where calmer water prevailed.

3.5.2 Gill Net Catches

Walleye spawning activity occurs at night and often only over a period of a few days (Ryder 1977). Such nocturnal fish movements would have been missed in the diving observations which were made during the daytime. The gill net catch data were intended to provide information on fish that may move into the discharge at night. In addition, the catch data provided a picture of the fish composition at the periphery of the discharges at times of the year that were not included in the regular May to November fish surveys.

Gill net catches are presented in Table 10 for the Pickering NGS A discharge and in Table 11 for the Pickering NGS B discharge.

Pickering NGS A Discharge

Gill nets were set on five occasions between March 15 and April 26 at the periphery of the Pickering NGS A discharge. A total of 289 fish belonging to 14 species were taken in the six nets. Gizzard shad, followed by white sucker, was the most abundant species in the total catch. Among the more common species in the remainder of the catch were lake trout, brown trout, alewife and white perch.

Gizzard shad were only caught on three occasions, with 67 out of 78 fish taken on March 25. White sucker, lake trout, brown trout and white perch were taken on all fishing occasions. As in 1987, no walleye were taken in the Pickering NGS A nets.

During the 1988 May to November gill netting program, alewife was the most abundant species taken in nets set at the Pickering NGS A discharge followed by white sucker, and then brown trout and round whitefish. Average catch of gizzard shad in May-November (2.1) was considerably lower than it was in March-April (13.0). May-November CUE of white sucker (6.9), lake trout (1.6), brown trout (5.9), and white perch (3.2) were also lower than their March-April average catches. Alewife CUE during the May-November survey was substantially higher (110.8) than that obtained in March-April (5.8).

Species taken in the gill nets, but not observed during the dives included rainbow smelt, brown trout, lake trout, lake whitefish and lake chub. Differences in species observed by divers and species composition of the gill net catches are not unexpected since the nets were set at the periphery of the discharges while dives were limited to the discharge channel.

TABLE 10

PICKERING NGS POSTOPERATIONAL STUDY - YEAR III, 1988
PICKERING NGS A DISCHARGE GILL NET CATCH

	*Mar 15	Mar 25	Apr 6	Apr 14	Apr 19	Apr 26	Total	CUE
	Number of fish							
ALEWIFE	16	2	7	3	1		29	5.8
RAINBOW SMELT				2			2	0.4
WHITE SUCKER	2	6	10	27	4	6	55	11
BROWN TROUT	2	6	12	9	1	2	32	6.4
BROWN BULLHEAD		1	1				2	0.4
LAKE TROUT	1	7	19	4	6	5	42	8.4
LAKEWHITEFISH				1			1	0.2
WHITE PERCH	2	8	4	6	2	2	24	4.8
RAINBOW TROUT			1				1	0.2
GIZZARD SHAD		67	7		4		78	13.0
CARP		1					1	0.2
LAKE CHUB	1			1			2	0.4
YELLOW PERCH		6	1	2		1	10	2.0
WHITE BASS		1	2		3	4	10	2.0
Total	24	105	64	55	21	20	289	57.8

TABLE 11

PICKERING NGS B POSTOPERATIONAL STUDY - YEAR III, 1988
PICKERING NGS B DISCHARGE GILL NET CATCH

	Mar 15	Mar 25	Apr 6	Apr 14	Apr 19	Apr 26	Total	CUE
	Number of fish							
ALEWIFE	7					19	26	4.3
WHITE SUCKER	4	2		2			8	1.3
BROWN TROUT	3	2	2	4	2		13	2.2
LAKE TROUT	15	12	5	1	1	1	35	5.8
GIZZARD SHAD	96	89	36	21		45	287	47.8
LAKE WHITEFISH				1			1	0.2
BROWN BULLHEAD	1		1	1			3	0.5
RAINBOW TROUT		1					1	0.2
ROCK BASS				1			1	0.2
WHITE PERCH	32	21	14	9	1	1	78	13.0
FRESHWATER DRUM	2		1				3	0.5
WHITE BASS	4	1	2	10	1	2	20	3.3
WALLEYE	1					3	4	0.7
TOTAL	165	128	61	50	5	71	480	80.0

Pickering NGS B Discharge

Gill nets were also set on six occasions in the Pickering NGS B discharge between March 15 and April 16. A total of 480 fish representing 13 species were taken in the six nets. Gizzard shad, followed by white perch, was the most abundant species in the total catch. Lake trout, alewife and white bass were among the common species present in the remainder of the catch.

Gizzard shad were caught in five of the six nets and were taken in higher numbers in March than in April. White perch, lake trout and white bass were taken in all nets while alewife were only taken in two net sets. A total of four walleye were caught in two net sets. Gizzard shad average catch was substantially higher in March-April (47.8) than in the May-November survey (2.1). March-April CUE's of white perch (13.0), lake trout (5.8) and white bass (3.3) were also higher than their May-November CUE's (2.2, 3.4 and 0.7, respectively). Average catch of alewife was substantially lower in March-April (4.3) than in May-November (123.7).

Lake whitefish was the only species taken in the gill net catch that was not observed by divers in the Pickering NGS B discharge channel.

In the 1987 report (Ontario Hydro Research Division Report No 88-267-K) it was suggested that the absence of walleye from the gill net catches may have indicated that there were no large influxes of spawning walleye into the discharges. However, observations made at Atikokan TGS and Big Chute on spawning walleye suggest that walleye swim very close to shore as they enter their spawning grounds. The placement of our nets at the centre of the mouth of the discharge channel precluded catching fish that were close to shore. Thus the placement of our nets and the limit of observations to daytime can easily account for missing walleye spawning in the discharges if it does occur. The presence of walleye eggs in the intake entrainment samples at Pickering NGS B in 1988, as well as the presence of a juvenile walleye in the stomach of a brown trout caught at the Pickering NGS A discharge, suggest that spawning may occur in the vicinity of the station.

4.0 SUMMARY AND CONCLUSIONS

1. White sucker, carp, smallmouth bass, white bass, yellow perch, and walleye were present in the Pickering NGS A discharge on most diving occasions between March 22 and June 21, 1988.

2. Carp was the most common species present in the Pickering NGS A discharge on dives made between March 22 and May 4, and white bass was the most common species present on May 25. Either alewife or white sucker were the most abundant species present during the June dives.

3. White sucker, carp, gizzard shad, smallmouth bass, white bass, freshwater drum, walleye, American eel and rock bass were present in the Pickering NGS B discharge during most of the dives made between March 22 and June 14, 1988.

4. Carp was the most abundant species present in the Pickering NGS B discharge during dives made between March 22 and June 14, and alewife was the most abundant species present on the remaining two diving occasions.

5. Gamefish such as smallmouth bass, white bass and walleye were relatively abundant in the discharges during the winter and appear to be attracted to them.

6. Although more smallmouth bass nesting activity was noted in the Pickering NGS A discharge in 1988 than in 1987, as in that year, no successful nesting was observed. The lack of success was attributed, in part, to low lake water levels and shoreline orientation which contributed to physical disturbances of guarding males and fry in the nest.

7. More smallmouth bass spawning activity was observed in the Pickering NGS B discharge than in the Pickering NGS A discharge. As in 1987, smallmouth bass spawning occurred along the west side of the Pickering NGS B discharge channel. Nesting activity was in progress on the first observation day, May 25, and continued to July 11. The total number of active nests (with eggs or fry) located during the peak spawning period on May 30 was 9. A total of 34 nesting attempts and 20 active nests were observed over the study period. The nests were located in protected areas where the water was calm, preventing offshore displacement and entrainment of larvae through the condenser cooling system. The spawning of smallmouth bass in the Pickering NGS B discharge may result in an increase in the local population by providing suitable spawning habitat. However, it is not known whether smallmouth bass spawning in the discharges has resulted in recruitment to the local population.

8. Gizzard shad were not present in very high numbers in either discharge, although they were more common in the Pickering NGS B discharge than the Pickering NGS A discharge. Relatively low numbers observed during the present study, as well as during the 1987 study, does not preclude the possibility of massive impingement of gizzard shad at Pickering NGS since the number of winter observations in both years were limited. In addition, impingement records of gizzard shad indicate that yearly fluctuation can be considerable.

9. Walleye were present in the discharges on all diving days except June 28. They were more common in the Pickering NGS B discharge than in the Pickering NGS A discharge, as they were in 1987. Although no large influxes of walleye were observed at their expected spawning time, their position in the discharge suggested that they were, as hypothesized at the scoping workshop, attracted to the discharge by the strong currents. In addition, since walleye spawning occurs at night, the daytime diving observations do not preclude the possibility that walleye may run into the discharges at night.

10. Gill net catches at the periphery of the discharges gave no indication of large influxes of walleye into the discharges during their expected spawning period. However, recent observations at other Ontario Hydro study sites, indicated that walleye swim very close to shore as they enter their spawning grounds. The placement of our nets at the centre of the

mouth of the discharge precluded catching fish that were close to shore. The presence of eggs in entrainment samples collected at Pickering NGS in 1988, as well as the presence of a juvenile walleye in the stomach of a brown trout caught at the Pickering NGS A discharge during the 1988 fish survey suggest that walleye spawn in the area of Pickering NGS.

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APPENDIX: 1

LOCATION OF FISH SPECIES OBSERVED WITHIN PICKERING A DISCHARGE CHANNEL
MARCH 22 - JUNE 21,1988

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	MARCH 22						
SPECIES:	SMB	3	5	4	5	5	22
	FWD			1	6		7
	WS	1	1			2	4
	CARP	15	150	15	81	75	336
	LMB	1					1
	GS		6		2		8
	WALLEYE		7	1			8
	WB					1	1
	W. PERCH		50		1		51
	GOLDFISH				1		1

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	APRIL 12			NS			
SPECIES:	WS		6		20		26
	CARP	12	30		10	10	62
	SMB	4	4		2	1	11
	WB	20					20
	FWD	4					4
	WALLEYE	6	2		3	2	13
	GS				2		2
	B BULLHEA	15					15
	C CATFISH	1					1
	AMER. EEL	1					1
	LOGPERCH					2	2

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	MAY 4						
SPECIES:	SMB	1	14		8	12	35
	WS	5	15	14	30	6	70
	WB	4	15	4	95	6	124
	WALLEYE	1	1		6	10	18
	CARP		40	25	37	78	180
	FWD		8		2	7	17
	Y. PERCH				2	2	4
	GS				20		20
	BB					1	1
	LOGPERCH					4	4

APPENDIX: 1 (CONTINUED)
LOCATION OF FISH SPECIES OBSERVED WITHIN PICKERING A DISCHARGE CHANNEL
MARCH 22 - JUNE 21, 1988

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	MAY 25						
SPECIES:	WALLEYE	2	10	2		3	17
	SMB	10	17	2	24	9	62
	WS	21	7	86	32	18	164
	CARP	5	26	33	5	13	82
	GS		9		5	40	54
	AMER. EEL		1				1
	Y. PERCH		25	4	20		49
	SCULPIN		1				1
	FWD			7		3	10
	WB			75	115	40	230
	BULLHEAD			8			8
	LNS				33		33
	LMB				1		1
	ROCK BASS				6		6
	B. CRAPPIE					1	1
	C. CATFISH					1	1

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	JUNE 2						
SPECIES:	LNS	26	4	550	16	33	629
	WS	13	75	140	69	7	304
	FWD	10	4				14
	CARP	9	8	4	14	6	41
	WALLEYE	3	2	8		1	14
	WB			100	1	75	176
	SMB		9		14	2	25
	ALEWIFE			400			400
	LMB			1			1
	Y. PERCH				3		3

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	JUNE 9						
SPECIES:	WS	21	58	10	95	25	209
	SMB	9		9	6		24
	C. CATFISH		1				1
	CARP		36	2	6	7	51
	AMER. EEL		3		1		4
	W. PERCH		2				2
	WALLEYE		1		1	1	3
	WB			75	70	30	175
	LNS				1		1
	Y. PERCH				1		1
	ROCK BASS					1	1

APPENDIX: 1 (CONTINUED)

LOCATION OF FISH SPECIES OBSERVED WITHIN PICKERING A DISCHARGE CHANNEL
MARCH 22 - JUNE 21, 1988

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	JUNE 17					*	
SPECIES:	SMB	1	7	2	6	15	31
	WALLEYE	1					1
	CARP	11	31	3	7	2	54
	WS	5	31	37	423	11	507
	W. PERCH		1	50	6	150	207
	ALEWIFE		200				200
	RBT		1				1
	Y. PERCH		6		5		11
	SALMONID				1		1
	ROCK BASS				1		1
	PUMPKINSEED					2	2

* no observations made north of pipe due to poor visibility.

PK A DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	TOTAL
DATE:	JUNE 21						
SPECIES:	CARP	6	8	5	8	4	31
	WALLEYE	1					1
	ALEWIFE	250	1300		600	75	2225
	WS	15	26	60	71	47	219
	C.CATFISH	1					1
	WB		5		28	14	47
	LNS		1		7		8
	ROCK BASS		1			1	2
	AMER. EEL		1				1
	SMB		4	1	13	10	28
	FWD				1		1
	Y. PERCH				3	2	5
	N. PIKE				1		1
	W. PERCH				25		25
	LAMPREY					1	1

APPENDIX: 2

LOCATION OF FISH SPECIES OBSERVED WITHIN PICKERING B DISCHARGE CHANNEL

MARCH 22 - JUNE 28,1988

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	MARCH 22								
SPECIES:	WB	1	25	6			10		42
	WP	2	9	2	1				14
	FWD		9	9	6			2	26
	SMB	7	13	12	15	8	10	2	67
	WALLEYE	2	14	3	24	2		1	46
	CARP	50	90	150	200	124	230	50	894
	WS	1	5	3	2			8	19
	GOLDFISH		1						1
	GS	1	6	6	18			12	43
	AMER. EEL		1						1
	BULLHEAD						1		1

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	APRIL 12								
SPECIES:	Y.PERCH	1							1
	ROCK BASS	1							1
	BULLHEAD	1							1
	CARP	15	36	5	25	100	130	45	356
	WALLEYE	2	3	13	4		13	4	39
	L. TROUT	1							1
	RBT		1						1
	SMB	1	1	1	10	4	9	3	29
	FWD	1			3			6	10
	WS		2	4	2			1	9
	GS				100	1	4	150	255
	W. BASS							2	2

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	MAY 4								
SPECIES:	SMB	1	1	2	13	8	6	5	36
	GS				3			6	9
	CARP	6	75	36	48	16	94	60	335
	W. PERCH								0
	FWD		6	6	4			1	17
	W. BASS					1			1
	WALLEYE	2	1	20	1			1	25
	AMER. EEL		1				3		4
	WS			8	3		12	10	33

APPENDIX: 2 (CONTINUED)

LOCATION OF FISH SPECIES OBSERVED WITHIN PICKERING B DISCHARGE CHANNEL

MAR 22 - JUNE 28,1988

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE	MAY 11								
SPECIES:	SMB	1			1		7	15	24
	B.CRAPPIE	1							1
	W. BASS	1	2			19		1	23
	Y. PERCH	6							6
	CARP	18	23	16	10	44	62	24	197
	WS	2	11				57	2	72
	FWD		6		1	2	8		17
	GS			1		2			3
	PMPKNSEED	1					1		2
	ROCK BASS						4		4
	AMER.EEL						5		5
	WALLEYE						1		1
	N. PIKE							1	1

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	MAY 24, 88								
SPECIES:	ROCK BASS	5							5
	W BASS	6		3			18		27
	SMB	5			9	5	22		41
	CARP	18	23	21	70	38	86	30	286
	B BULLHEAD	6				11		3	20
	WH SUCKER		9	10	6		9	3	37
	W PERCH				7				7
	WALLEYE				12		1		13
	A EEL						5		5
	FWD						1	2	3
	Y PERCH							1	1
	GOLDFISH							1	1

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	MAY 31, 88								
SPECIES:	W BASS	1		1	1	22	1		26
	PUMPKINSEED	1							1
	L BASS	1				1			2
	A EEL	1	1			9	5		16
	W SUCKER	2	11	8	10	3	14	3	51
	CARP	8	23	20	34	47	39	1	172
	SMB		4		7	3	11	3	28
	W PERCH		3		3	3			9
	WALLEYE			8				2	10
	Y PERCH				6		2	1	9
	BR TROUT				20				20
	GOLDFISH				1				1
	FWD				2			1	3

APPENDIX: 2 (CONTINUED)
LOCATION OF FISH SPECIES OBSERVED WITHIN PICKERING B DISCHARGE CHANNEL
MAR 22 - JUNE 28,1988

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	JUNE 9, 88								
SPECIES:	CARP	26	52	21	11	53	60	41	264
	W SUCKER	8	35	24	19	4	40	19	149
	FWD	4	6	1		1	1	1	14
	R BASS	6					2		8
	W BASS	1		2	1			2	6
	A EEL	1	1			1	5		8
	SMB	1		5	16	3	29	27	81
	L SUCKER						7		7
	WALLEYE	2	8				4	2	16
	GZS				55				55

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	JUNE 14, 88								
SPECIES:	W SUCKER	10	18	7	13		31	20	99
	A EEL	6	4		5				15
	CARP	30	30	19	23	43	39	54	238
	FWD	2	3	3	3	1		1	13
	PUMKINSEED	1			1			1	3
	L SUCKER		1				1		2
	R BASS				4		3	3	10
	Y PERCH				6				6
	SMB				38	2	42	24	106
	GZS				2	2	1		5
	WALLEYE				1	1	4	1	7
	W BASS						36		36

PK B DISCHARGE		LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE:	JUNE 21, 88								
SPECIES:	FWD	3	6	2	3		5	7	26
	W PERCH	1							1
	A EEL	2							2
	ALEWIFE	1000		10	10	750			1770
	CARP	30	27	11	13	50	70	47	248
	W BASS	25	5			2	40		72
	W SUCKER	15	11	12	1	1	37	28	105
	WALLEYE			2	1		2	10	15
	PUMPKINSEED				6	1			7
	Y PERCH				3			2	5
	R BASS				4			4	8
	SMB				7	1	11	29	48
	GZS				3				3

APPENDIX: 2 (CONTINUED)

LOCATION OF FISH SPECIES OBSERVED WITHIN PICKERING B DISCHARGE CHANNEL

MAR 22 - JUNE 28,1988

PK B DISCHARGE	LOC.1	LOC.2	LOC.3	LOC.4	LOC.5	LOC.6	LOC.7	TOTAL
DATE: JUNE 28, 88								
SPECIES: ALEWIFE	2000	100	NS	NS	2240	80	NS	4420
CARP	10	6			24	19		59
R BASS		1						1
W BASS					37	41		78
W SUCKER					9	20		29
A EEL					6	1		7
SMB						1		1

APPENDIX: 3
OBSERVATIONS ON SMALLMOUTH BASS NESTS,
PICKERING NGS B POST OPERATIONAL STUDY, 1988

NEST #: 1 DEPTH(CM) 62

LOCATION:BEHIND ROCK # 7

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 25	0	0		
MAY 27	0	0		
MAY 30	0	0		
JUNE 1	0	0		
JUNE 3	0	0		
JUNE 6	0	0		PARTIALLY SILTED OVER
JUNE 8	0	0		SILTED OVER

NEST #: 2 DEPTH(CM) 100

LOCATION:DISCHARGE SIDE OF ROCK # 11

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 25	1	1		EGGS, ONE TAKEN
MAY 27	1	1	TERRITORIAL & PROTECTIVE	NEST LOOKS SILTED OVER
MAY 30	1	3-4		
JUNE 1	1	4	PROTECTIVE	10% OF FRY RISEN UP TO 10 CM OFF BOTTOM
JUNE 3	1	6		10% OF FRY RISEN UP TO 20 CM OFF BOTTOM
JUNE 6	1	8		FRY 1-1.5 CM IN LENGTH 35 CM OFF BOTTOM
JUNE 8	0	8		NEST AREA SILTED
JUNE 10	0	8		FRY DISPERSED AROUND AND BEHIND ROCK
JUNE 13	1	0		NEST AREA CLEAN
JUNE 15	1	0		CLEAN
JUNE 17	0	0		
JUNE 20	1	0		
JUNE 23	0	0		

APPENDIX: 3 (CONTINUED)

NEST #: 3 DEPTH(CM) 85

LOCATION:BETWEEN TWO LARGE ROCKS,SECOND ROW IN;BEHIND ROCK # 4

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 25	0	0		
MAY 27	0	0		
MAY 30	1	0		DIFFICULT TO SEE NEST OR CHECK FOR EGGS
JUNE 1	0	0		
JUNE 3	0	0		
JUNE 6	1	0		
JUNE 8	1	0		
JUNE 10	1	0		AREA STILL CLEAN
JUNE 13	1	1		
JUNE 15	0	0		EGGS GONE
JUNE 17	0	0		
JUNE 20	0	0		

NEST #: 4 DEPTH(CM) 87

LOCATION:BETWEEN ROCKS 9 & 10

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 25	0	0		
MAY 27	1	0		
MAY 30	0	0		
JUNE 1	0	0		SILTED OVER
JUNE 3	0	0		
JUNE 6	0	0		
JUNE 8	0	0		

APPENDIX 3: (CONTINUED)

NEST #: 5 DEPTH(CM) 120

LOCATION:DIRECTLY BEHIND ROCK # 11

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 25	1	?	TERRITORIAL	COULD NOT EXAMINE CLOSELY
MAY 27	1	4	TERRITORIAL AND PROTECTIVE	
MAY 30	1	8	TERRITORIAL	FRY DISPERSED THROUGH WATER COLUMN
JUNE 1	1	8		AS ABOVE
JUNE 3	0	8		AS ABOVE
JUNE 6	1	8		20% WITHIN 6 CM OF BOTTOM REST 20-30 CM OFF BOTTOM
JUNE 8	1	8		ONLY A FEW FRY
JUNE 10	1	8		LARGE RISEN FRY
JUNE 13	1	8		
JUNE 15	0	8		LARGE RISEN FRY FROM SURFACE TO BOTTOM
JUNE 17	2	9		
JUNE 20	1	9		
JUNE 23	1	9		
JUNE 27	1	9		
JUNE 29	1	9		2 LARGE FRY
JUNE 30	1	0		AREA CLEAN
JULY 4	0	0		

NEST #: 6 DEPTH(CM) 168

LOCATION:11 METERS NORTH OF "DANGEROUS WATERS" SIGN,2.5 METERS OFFSHORE
3 METERS SOUTH OF NEST # 7.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 25	0	0		
MAY 27	0	0		SILTED OVER
MAY 30	0	0		
JUNE 1	0	0		

APPENDIX: 3 (CONTINUED)

NEST #: 7 DEPTH(CM) 160

LOCATION: 2 METERS OFFSHORE, IN FRONT OF DRIFTWOOD PILE ON SHORE, APPROX. 5 METERS NORTH OF NEST # 6

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 27	1	0		
MAY 30	1	1		
JUNE 1	0	0		
JUNE 3	0	0		STILL CLEAN
JUNE 6	0	0		SILTING OVER
JUNE 8	0	0		BADLY SILTED

NEST #: 8 DEPTH(CM) 172

LOCATION: APPROX. 15 METERS NORTH OF NEST # 7, JUST NORTH OF MAPLE STUMP AND SECOND GROWTH ON SHORELINE, 2 METERS OFFSHORE

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 25	2	0		
MAY 27	0	0		
MAY 30	1	6	PRESENT	BLACK FRY UP TO 10 CM OFF BOTTOM
JUNE 1	2	8		30-40 BLACK FRY APPROX. 30-40 CM OFF BOTTOM
JUNE 3	1	8		OVER 100 FRY, 40 CM OFF BOTTOM
JUNE 6	1	8		FRY COLLECTED
JUNE 8	0	8		5 LARGE FRY NEAR BOTTOM NEST AREA SILTED
JUNE 10	0	0		FRY ABSENT
JUNE 13	0	0		
JUNE 15	1	0		NEST AREA CLEANED
JUNE 17	0	0		
JUNE 20	0	0		CLEAN
JUNE 23	0	0		
JUNE 27	1	0		
JUNE 29	1	0		CLEAN
JULY 4	0	0		CLEAN
JULY 7	1	0		CLEAN

NEST #: 9 DEPTH(CM) 165

LOCATION: DIRECTLY BEHIND ROCK # 12, BETWEEN TWO ROCKS IN THE SECOND ROW

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 27	1	0		
MAY 30	1	1	GUARDING	EGGS
JUNE 1	1	6		FRY RISEN 15-40 CM OFF BOTTOM
JUNE 3	0	8		FRY RISEN HALF WAY THRU WATER COLUMN
JUNE 6	1	8		FRY MOSTLY NEAR BOTTOM WITHIN 10 CM.
JUNE 8	0	8		FRY WITHIN 15 CM. OF BOTTOM
JUNE 10	0	0		NO FRY IN AREA OF NEST
JUNE 13	1	0	DIFFERENT MALE	
JUNE 15	0	0		
JUNE 17	0	0		
JUNE 20	0	0		SILTED OVER

NEST #: 10 DEPTH(CM) 160

LOCATION: BEHIND ROCKS 14 AND 15, IN THE SPACE BETWEEN THEM AND THE ROCK DIRECTLY WEST OF THEM.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 30	1	1		
JUNE 1	1	0	PRESENT	
JUNE 3	1	6		MANY FRY
JUNE 6	1	8		DISPERSED THRU WATER COLUMN AROUND ROCK # 15.
JUNE 8	1	8		AS ABOVE
JUNE 10	1	8		AS ABOVE
JUNE 13	1	8		
JUNE 15	0	0		SILTED
JUNE 17	0	0		
JUNE 20	0	8		A FEW FRY NORTH OF ROCK # 14
JUNE 23	0	0		
JUNE 27	0	0		
JUNE 29	0	9		5 OLIVE-BROWN FRY AT NORTH END OF ROCK # 14
JUNE 30	0	0		CLEAN
JULY 3	0	0		CLEAN

APPENDIX: 3 (CONTINUED)

NEST #: 11 DEPTH(CM) 160

LOCATION: NEST ON WEST SIDE OF SINGLE LARGE ROCK LOCATED ON SHELF APPROX. 4 METERS FROM SHORE IN FRONT OF ROCK # 11.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 27	2	0		
MAY 30	1	1		MUCOUS TYPE MATERIAL AND SOME EGGS
JUNE 1	1	0	PRESENT, BUT NOT AGGRESSIVE	
JUNE 3	1	0		
JUNE 6	0	0		
JUNE 8	0	0		SILTED OVER
JUNE 10	1	0		
JUNE 13	0	0		
JUNE 15	0	0		SILTED
JUNE 17	0	0		

NEST #: 12 DEPTH(CM) 167

LOCATION: DIRECTLY ACROSS FROM METEOROLOGICAL TOWER ON EAST SHORE, IN FRONT OF ROCKS 38 AND 39.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 27	0	0		
MAY 30	0	0		
JUNE 1	0	0		
JUNE 3	0	0		
JUNE 6	0	0		STILL CLEAN
JUNE 8	0	0		
JUNE 10	0	0		
JUNE 13	0	0		CLEAN
JUNE 15	0	0		SILTED OVER

NEST #: 13 DEPTH(CM) 159

LOCATION: ACROSS FROM METEOROLOGICAL TOWER ON EAST SHORE, 2 METERS SOUTH OF NEST # 12, ON OPPOSITE SIDE OF LARGE ROCK.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY27	1	0	TIMID, EASILY DISTURBED	
MAY 30	0	0		
JUNE 1	1	0	SMALL	
JUNE 3	1	0		
JUNE 6	0	0		SLIGHTLY SILTED
JUNE 8	0	0		SILTED OVER
JUNE 10	1	0		
JUNE 13	1	1		CLEANED , IN USE
JUNE 15	1	0		CLEAN
JUNE 17	0	0		
JUNE 20	1	0		CLEAN
JUNE 23	0	0		SILTED

NEST #: 15 DEPTH(CM) 173

LOCATION: 4 METERS OFFSHORE, 10 METERS SOUTH OF NEST 13

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 30	1	3		50% BLACK UNRISEN FRY
JUNE 1	1	4-6		80% BLACK UNRISEN 20% RISEN TO 10 CM
JUNE 3	1	8		APPROX. HALF WAY THRU WATER COLUMN
JUNE 6	0	8		NO FRY AT NEST SITE, SOME BEHIND ROCKS TO WEST OF NEST
JUNE 8	0	8		LARGE BLACK FRY NEAR BOTTOM,NEST SLIGHTLY SILTED
JUNE 10	0	0		NO FRY
JUNE 13	1	1		SECOND USE, 0.5 M. NORTH OF PREVIOUS NEST
JUNE 15	1	0	TIMID	CLEAN
JUNE 17	1	0		
JUNE 20	0	0		CLEAN
JUNE 23	0	0		SILTED OVER

APPENDIX: 3 (CONTINUED)

NEST #: 16 DEPTH(CM) 147

LOCATION:3 METERS OFFSHORE, 5 METERS SOUTH OF NEST 15

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 27	1	0		
MAY 30	1	1		
JUNE 1	1	0	EASILY DISTURBED	SILTED OVER
JUNE 3	1	0	SMALL	
JUNE 6	1	0		
JUNE 8	1	0		SILTED OVER
JUNE 10	0	0		
JUNE 13	0	0		SILTED OVER
JUNE 15	1	0	LARGE	CLEAN
JUNE 17	1	0		
JUNE 20	1	0	LARGE	SILTED
JUNE 23	1	0		PART. CLEANED
JUNE 27	0	0		CLEAN

NEST #: 17 DEPTH(CM) 170

LOCATION:4 METERS OFFSHORE IN FRONT OF ROCK # 15.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 30	1	0		
JUNE 1	1	0	TERRITORIAL	
JUNE 3	1	0		SILTED OVER
JUNE 6	0	0		
JUNE 8	0	0		
JUNE 10	0	0		
JUNE 13	1	0		
JUNE 15	0	0		CLEAN
JUNE 17	0	0		
JUNE 20	0	0		
JUNE 23	0	0		SILTED OVER

APPENDIX: 3 (CONTINUED)

NEST #: 18 DEPTH(CM) 180

LOCATION:3 METERS OFFSHORE IN FRONT OF ROCK 29.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 30	1	0		
JUNE 1	1	1	NERVOUS	EGGS OK
JUNE 3	0	0		
JUNE 6	0	0		SILTED OVER
JUNE 8	0	0		
JUNE 10	0	0		
JUNE 13	1	0		CLEAN
JUNE 15	1	0	TIMID BUT STAYS IN AREA	CLEAN
JUNE 17	1	0		
JUNE 20	0	0		SILTED OVER
JUNE 23	0	0		
JUNE 27	0	0		CLEAN
JUNE 29	0	0		SILTED

NEST #: 19 DEPTH(CM) 184

LOCATION:3 METERS OFFSHORE, 2.5 METERS SOUTH OF NEST 16.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 30	1	0		FRESHLY MADE
JUNE 1	1	0	NERVOUS	
JUNE 3	1	0	EASILY DISTURBED	
JUNE 6	0	0		
JUNE 8	0	0		
JUNE 10	0	0		CLEAN
JUNE 13	0	0		SILTED
JUNE 15	0	0		
JUNE 17	0	0		SILTED

APPENDIX: 3 (CONTINUED)

NEST #: 20 DEPTH(CM) 180

LOCATION:2 M. OUT FROM ORANGE TAPED REINFORCING ROD, IN FRONT OF ROCK 16

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
MAY 30	1	0	AGGRESSIVE	
JUNE 1	1	1	AGGRESSIVE	EGGS SLIGHTLY FUNGUSED
JUNE 3	0	0		
JUNE 6	0	0		
JUNE 10	0	0		ABANDONED
JUNE 13	0	0		
JUNE 15	2	0	TIMID	PART. CLEANED
JUNE 17	1	0		
JUNE 20	2	0		MODER. CLEAN
JUNE 23	0	0		SILTED OVER
JUNE 27	0	0		SILTED OVER

NEST #: 21 DEPTH(CM) 178

LOCATION:3 METERS OFFSHORE, 3 METERS NORTH OF NEST 16

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 1	1	0	TERRITORIAL	FRESHLY MADE
JUNE 3	1	0		
JUNE 6	1	0		
JUNE 8	0	0		
JUNE 10	0	0		
JUNE 13	0	0		SILTED
JUNE 15	0	0		SILTED

APPENDIX: 3 (CONTINUED)

NEST #: 22 DEPTH(CM) 190

LOCATION:2 METERS SOUTH OF AND 1 METER EAST OF NEST 13

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 3	2	0		FRESHLY MADE
JUNE 6	0	0		ABANDONED
JUNE 8	0	0		SILTED OVER
JUNE 10	0	0		
JUNE 13	0	0		CLEANED
JUNE 15	1	0		CLEAN
JUNE 17	0	0		
JUNE 20	0	0		

NEST #: 23 DEPTH(CM) 160

LOCATION: BETWEEN FRONT EDGE OF ROCKS 13 AND 14

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 10	1	0		FRESHLY MADE
JUNE 13	0	0		UNUSED
JUNE15	0	0		SILTED OVER
JUNE 17	0	0		
JUNE 20	0	0		SILTED OVER

NEST #: 24 DEPTH(CM):

LOCATION:15 METERS SOUTH OF RADIOTELEMETRY TOWER, 3 METERS OFFSHORE

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 10	2	0		FRESHLY MADE
JUNE 13	0	0		SILTED

NEST #: 25 DEPTH(CM) 175

LOCATION:2.5 METERS OFFSHORE IN FRONT OF ROCKS 24 AND 25

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 13	1	1	TERRITORIAL	LARGE,CLEAN
JUNE 15	0	0		CLEAN
JUNE 17	0	0		
JUNE 20	1	0		
JUNE 23	0	0		SILTED OVER
JUNE 27	0	0		SILTED OVER

NEST #: 26 DEPTH(CM) 185

LOCATION:1 METER SOUTH OF NEST 19

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 13	1	1		FEW EGGS
JUNE 15	1	0	LARGE	
JUNE 17	0	0		
JUNE 20	0	0		SILTED OVER
JUNE 23	1	0		MARGINAL SILT COVER
JUNE 27	0	0		SILTED OVER

NEST #: 27 DEPTH(CM) 150

LOCATION:APPROX. 2 METERS SOUTHEAST OF NEST 7, 1.5 METERS FROM SHORE.

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 15	1	1	LARGE,BLACK	EGGS CLEAR,NEST NOT VERY CLEAN
JUNE 17	1	0		
JUNE 20	0	0		SILTED OVER
JUNE 23	0	0		MARGINAL
JUNE 27	0	0		CLEAN
JUNE 29	1	0		CLEAN
JULY 4	0	0		
JULY 7	0	0		CLEAN

APPENDIX: 3 (CONTINUED)

NEST #: 28 DEPTH(CM) 180

LOCATION: BETWEEN NESTS 19 AND 26, BUT CLOSER TO SHORE, BETWEEN TWO ROCKS

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 20	1	0	LARGE	CLEAN
JUNE 23	0	0		STARTING TO SILT
JUNE 27	0	0		SILTED OVER

NEST #: 29 DEPTH(CM):

LOCATION: HALF WAY BETWEEN OUTER "DANGEROUS WATERS" SIGN AND END OF SHORELINE

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 17	0	0		FRESH NEST
JUNE 20	0	0		

NEST #: 30 DEPTH(CM):

LOCATION: 20 METERS SOUTH OF RADIOTELEMETRY TOWER, 3 METERS OFFSHORE

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JUNE 23	2	1		FRESHLY MADE
JULY 4	1	0		CLEAN

APPENDIX: 3 (CONTINUED)

NEST #: 31 DEPTH(CM):

LOCATION:75 METERS FROM END OF SHORELINE

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JULY 4	1	1	LARGE	CLEAN
JULY 7	0	0		CLEAN
JULY 11	0	0		SILTED OVER

NEST #: 32 DEPTH(CM):

LOCATION:70 METERS FROM END OF SHORELINE

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JULY 7	0	1		CLEAN, 20-30 EGGS
JULY 11	0	0		EGGS GONE

NEST #: 33 DEPTH(CM):

LOCATION:85 METERS FROM END OF SHORELINE

DATE	PRESENCE CODE	NEST CODE	REMARKS ON MALE	REMARKS ON NEST
JULY 4	1	0	SMALL	CLEAN, UNDER SHELF
JULY 7	1	0		
JULY 11	1	0		